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TECHNICAL REPORT ARLCD-TR-81010

U.S. (ARRADCOM) TEST RESULTS FOR NATO ROUND-ROBIN TEST ON HIGH EXPLOSIVES

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MAY 1981

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Report ARLCD-TR-81010	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) U.S. (ARRADCOM) TEST RESULTS FOR NATO ROUND-ROBIN TEST ON HIGH EXPLOSIVES		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) L. Avrami M.S. Kirshenbaum		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS ARRADCOM, LCWSL Energetic Materials Div (DRDAR-LCE-D) Dover, NJ 07801		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS ARRADCOM, TSD STINFO Div (DRDAR-TSS) Dover, NJ 07801		12. REPORT DATE May 1981 13. NUMBER OF PAGES 55
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Explosives	Picatinny Arsenal 10% point	Tetryl
Impact sensitivity	Run-down test	RDX
Picatinny Arsenal impact tester	Thermal sensitivity	HMX
ERL (NOL) impact tester	Explosion temperature	TNT
50% Bruceton test	PETN	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

As part of the NATO Round-Robin Test program using explosives from one source, the US (ARRADCOM) performed a series of tests on five BICT-furnished explosives. The explosives tested were PETN, RDX, HMX, tetryl and TNT. A series of impact tests were conducted utilizing the 50% Bruceton, the Picatinny Arsenal 10% point and the full run-down test methods. Additional tests, including melting point, chemical analysis, vacuum stability test, explosion temperature, DTA/TGA, DSC, IR, NMR and particle size distribution, (cont)

20. ABSTRACT (cont)

were conducted. For impact sensitivity and thermal sensitivity, relative rankings for the explosives were determined.

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INTRODUCTION

In compliance with a request of NATO AC 225, Panel IV, Subpanel 2 during its November 1976 meeting, the United States participated in a Round-Robin test program with explosives coming from the same source. The purpose of the program was to develop and standardize methods for characterizing the sensitivity of explosives for main and booster explosives. Each participating country was to test the identical explosives with its own procedures and equipment so that the sensitivity data developed would give information on sensitivity levels leading to relative rankings for acceptance criteria.

The NATO nations who participated in the Round-Robin test program were Belgium, Federal Republic of Germany, France, Italy, The Netherlands, United Kingdom, and the United States. For the United States the tests were performed by the Energetic Materials Division, Large Caliber Weapon Systems Laboratory, U.S. Army Research and Development Command, (ARRADCOM), Dover, NJ 07801.

The five candidate explosives selected for the program were PETN, HMX, RDX, TNT, and tetryl. These materials were obtained and distributed by Bundesinstitut fur chemisch-technische Untersuchungen (BICT), Federal Republic of Germany. The analytical data on these materials are listed in a BICT document dated 7 April 1978, which is included in the appendix.

TEST PROGRAM

For the United States the following sensitivity and characterization tests were conducted on the five BICT-furnished explosives:

Impact Sensitivity Tests

Picatinny Arsenal Impact Tester

Full curve - 20 samples per point
50% Point (Bruceton method)
10% Point (Picatinny Arsenal method)

ERL (NOL) - Type 12 Impact Tester

Full curve -20 samples per point
50% Point (Bruceton method)
10% Point (Picatinny Arsenal method)

Thermal Sensitivity

Melting point
373 K (100°C) vacuum stability test
Explosion temperature test
Differential thermal analysis/thermogravimetric analysis (DTA/TGA)
Differential scanning calorimetry (DSC)

Electrostatic sensitivity test
Infrared spectroscopy (IR)
Nuclear magnetic resonance (NMR)
Chemical analyses
Particle size distribution

RESULTS

The test program began with a drying period. Each of the explosives were placed in a vacuum oven at 333 K (60°C) over a weekend and then sieved through a 1mm mesh coarse screen.

Impact Sensitivity

The impact sensitivity tests were performed on the Picatinny Arsenal (PA) (now ARRADCOM) impact apparatus and the ERL (NOL) Type 12 Tool impact tester. The PA impact tester utilizes a 2-kg dropweight (refs 1,2) with the sample in a confined environment. The ERL impact apparatus uses a 2.5-kg dropweight with the sample resting on sandpaper between two anvils (refs 1,2).

The impact sensitivity tests were conducted in a controlled environment - 55% relative humidity at 293 K (20°C) (68°F).

Three test methods were conducted: the full run-down firing curve, (also known as the up-and-down or staircase method), the 50% Bruceton method, and the 10% Picatinny Arsenal point. The run-down and Bruceton methods are well known. The 10% PA point is the minimum height at which at least one of ten trials result in a reaction.

In all the impact tests performed any reaction, i.e. smell, burn, snap, noise, etc. is considered a "fire" or "go".

The results of the run-down tests on the Picatinny Arsenal impact apparatus are listed in table 1. For the same type of tests conducted on the ERL (NOL) Type 12 apparatus the results are listed in table 2.

Table 3 lists the 50% points obtained by the Bruceton up-down method for the NATO explosives as determined with the Picatinny Arsenal and the ERL apparatus. Included are the 10% firing points obtained with the two impact testers. As a comparison, the 50% and 10% points obtained from the full run-down curves of both testers are listed.

Thermal Sensitivity and Chemical Analysis

The following characteristics were determined for the five BICT-supplied NATO explosives: melting point (setting point), acidity (as sulfuric acid), purity, sodium content, insoluble matter, acetone insolubles, inorganic insolubles, nitrogen, and 373 K (100°C) vacuum stability test. The results are listed in table 5. Comparisons are made with the results listed in the appendix.

The confined explosion temperature test (ref 3) was conducted on the five explosives. The results are plotted in figure 1 and the time-to-explosion temperatures for 1-sec and 5-sec are listed in table 6. The results are compared with those of similar United States made explosives (ref 4).

The DTA/TGA thermograms were obtained simultaneously with the Mettler apparatus at a heating rate of 10 K per min. The DTA/TGA thermograms were run in air and nitrogen atmospheres. These are shown in figures 2 through 12. Table 7 lists the endotherms and exotherms, the start of decomposition, and the 10% weight loss temperature for each of the materials.

The DSC runs were obtained with a Perkin-Elmer apparatus, model DSC-1 at a heating rate of 10 K per min. The melting points and the rapid decomposition points (peak) for each of the explosives are listed in table 8.

Electrostatic Sensitivity

Each of the five explosives were subjected to the electrostatic sensitivity test (ref 1). The test was conducted at a voltage of 5000 VDC and a capacitance of 0.02 microfarad at ambient temperature - 293 K (20°C) - and a relative humidity of 55%. For all of the explosives no fires occurred in 20 consecutive tests for each explosive at the 0.25 joule level. This is the acceptance level for the interim qualification of explosives for military use.

Infrared Spectroscopy

The infrared spectra of the five NATO explosives were obtained and are shown in figures 13 through 17. Comparisons were made with IR spectra of United States made explosives (ref 5). The spectra were in close agreement with the referenced materials.

Nuclear Magnetic Resonance

Nuclear magnetic resonance spectra were obtained for a 10% solution of:

PETN in deuteroacetone, (fig. 18)
HMX in deuterodimethylsulfoxide,* (fig. 19)
RDX in deuterodimethylsulfoxide* (fig. 20)
Tetryl in deuteroacetone* (fig. 21)
TNT in deuteroacetone (fig. 22)

These NMR spectra (figs. 18 through 22) were compared to those published in reference 6 and they were found to be the same within experimental error. Integrals of the spectra for tetryl and TNT (figs. 23,24) show the expected peak area ratios (within experimental error) for the three methyl and two ring protons found in these compounds.

The procedures for obtaining the NMR spectra also are described in reference 6.

Particle Size Distribution

The particle size distribution for each of the NATO Round-Robin explosives was obtained by the sieve method. The percent retained on each sieve is noted in table 9.

CONCLUSIONS

For the NATO Round-Robin test program both the Picatinny Arsenal impact and the ERL (NOL) Type 12 Tool tests indicated that PETN was the most sensitive, and TNT the least sensitive explosive. However, HMX, tetryl, and RDX interchanged positions in the relative sensitivity ranking obtained for one impact tester when compared to the other.

A comparison was made not only between the test apparatus but also with the methods used. The Bruceton 50% point and the Picatinny Arsenal 10% point were compared to the same values obtained from the full run-down test data.

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* Black particles were seen in the solution but not in the powder.

The following points are observed with reference to the relative rankings:

1. The PA impact test produced the same relative sensitivity ranking based on the Bruceton 50% and PA 10% points:

PETN > HMX > tetryl > RDX > TNT

(In this connotation the term > means "more sensitive than")

Using the 50% and 10% points from the run-down tests to obtain relative rankings, the results were the same as above except that tetryl and RDX switched places (although HMX and RDX had almost the same value in the 10% point).

2. The ERL test produced the following relative ranking based on the 50% Bruceton point: PETN > tetryl > HMX > RDX > TNT. For the rankings obtained with the PA 10% point and the run-down 10% point, HMX and tetryl reversed positions. The run-down 50% point produced a ranking of PETN > HMX > RDX > tetryl > TNT.

3. The 50% Bruceton and PA 10% point on the Picatinny tester had produced the same rankings as that obtained with the PA 10% point with the ERL tester, namely PETN > HMX > tetryl > RDX > TNT. However, in the ranking obtained with the 50% Bruceton using the ERL tester, HMX and tetryl reversed positions.

4. In the run-down tests the 50% point on the Picatinny and ERL testers produced the same rankings, namely, PETN > HMX > RDX > tetryl > TNT. With the 10% point, RDX and tetryl reversed positions.

The ranking of the explosives in accordance with the explosion temperature test was as follows: PETN > tetryl > RDX > HMX > TNT.

Within experimental error the chemical analysis agrees with the data furnished in the appendix.

The explosion temperature data show some slight differences when comparing similar data obtained with similar United States made explosives. The DTA/TGA thermograms confirm the DSC data. In terms of thermal sensitivity the explosion temperature data agrees with the DTA/TGA and DSC data.

The IR and NMR spectra of each explosive were compared to referenced spectra and the traces are in agreement.

In the electrostatic sensitivity test no fires occurred for each explosive at the 0.25 joule level.

The data in this report is to be forwarded to BICT for analysis with the data generated by the other NATO participants.

REFERENCES

1. Joint Service Evaluation Plan for Preferred and Alternate Explosive Fills for Principal Munitions, Volume IV, Joint Service Safety and Performance Manual for Qualification of Explosives for Military Use, prepared by Joint Technical Coordinating Group for Air-Launched Non Nuclear Ordnance, 12 May 1972 (based on NAVORD Report OD-44811), (AD-A-086259).

2. G.R. Walker (Ed.), "Manual of Sensitiveness Tests," TTCP Panel O-2 (Explosives). Canadian Armament Research and Development Establishment, Valcartier, Quebec, Canada, February 1966.

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Table 1. Run-down test results of NATO round-robin explosives obtained with PA impact tester

Height		Explosives - percent fired				
cm	in.	PETN	HMX	RDX	Tetryl	TNT
12.7	5	0				
15.2	6	20				
17.8	7	15				
20.3	8	45				
22.9	9	50				
25.4	10	55				
27.9	11	55	0			
30.5	12	70	10			
33.0	13	80	10	0	0	
35.6	14	85	15	25	10	0
38.1	15	100	25	30	25	10
40.6	16		50	35	30	15
43.2	17		65	50	40	30
45.7	18		70	65	55	35
48.3	19		90	85	70	45
50.8	20		100	80	80	60
53.3	21			95	90	70
55.9	22			100	100	-
58.4	23					75
63.5	25					75
68.6	27					85
71.1	28					100

Conditions: (1) 2.5-kg dropweight
(2) 20 samples per height

Table 2. Run-down test results of NATO round-robin explosives obtained with ERL (NOL) impact tester

Height			Explosives - percent fired			
cm	in.	PETN	HMX	RDX	Tetryl	TNT
25.4	10	0	0			
33.0	13	25				
40.6	16	55				
50.8	20	70	10	0		
55.9	22	-	-		5	
63.5	25	100		15		
71.1	28				10	
76.2	30		30	10		0
88.9	35					10
101.6	40		65	50		20
106.7	42				55	
127.0	50		65	70		40
132.1	52				65	
152.4	60		90	90		70
157.5	62				80	
177.8	70		100	100		80
182.9	72				100	
203.2	80					50
228.6	90					75
279.4	110					95

Conditions: (1) 2.5-kg dropweight

(2) 20 samples per height

Table 3. Comparison of Bruceton 50% up-and-down and ARRADCOM 10% points with run-down test results

50% Firing Point

	Bruceton method			Run-down method		
	ARRADCOM tester		ERL (NOL) tester	ARRADCOM tester		ERL (NOL) tester
	in.	cm	cm	in.	cm	cm
Tetryl	17.00 ± 1.26	43.18 ± 3.18	31.95 ± 3.69	17.4	44.20	45.0
HMX	16.33 ± 0.54	41.48 ± 1.37	35.00 ± 1.80	16.0	40.64	39.0
RDX	17.25 ± 0.89	43.82 ± 2.26	45.33 ± 3.78	17.0	43.18	43.0
PETN	11.17 ± 1.76	28.37 ± 4.47	17.05 ± 2.22	9.5	24.13	16.3
TNT	19.08 ± 3.41	43.46 ± 8.66	44.00 ± 2.88	19.0	48.23	51.0

10% Firing Point

	ARRADCOM method			Run-down method		
	ARRADCOM tester		ERL (NOL) tester	ARRADCOM tester		ERL (NOL) tester
	in	cm	cm	in	cm	cm
Tetryl	14	35.6	29	14	36.6	25.0
HMX	10	25.4	21	12	30.5	18.0
RDX	15	38.1	31	12	30.5	28.0
PETN	6	15.2	10	6	15.2	10.0
TNT	16	40.6	35	15.4	39.1	33.0

Table 4. Relative ranking of NATO round-robin explosives according to impact sensitivity tests

a. ARRADCOM impact test

Bruceton 50 % pt	ARRADCOM 10% pt	Full run-down curve 50% pt	Full run-down curve 10% pt
PETN	PETN	PETN	PETN
HMX	HMX	HMX	HMX
Tetryl	Tetryl	RDX	RDX
RDX	RDX	Tetryl	Tetryl
TNT	TNT	TNT	TNT

b. ERL (NOL) impact test

Bruceton 50 % pt	ARRADCOM 10% pt	Full run-down curve 50% pt	Full run-down curve 10% pt
PETN	PETN	PETN	PETN
Tetryl	HMX	HMX	HMX
HMX	Tetryl	RDX	Tetryl
RDX	RDX	Tetryl	RDX
TNT	TNT	TNT	TNT

NOTE: The rankings are listed as the most to the least sensitive explosive.

Table 5. Characteristics of NATO high explosives

	PETN	HMX	Tetryl	RDX	TNT
Melting point (setting pt), K	412.6 - 413.8	540.0	401.8 - 402.5	474.9 - 475.5	351.0 - 352.8
°C	139.6 - 140.8	267.0	128.8 - 129.5	201.9 - 202.5	78.0 - 79.8
Acidity (as sulfuric acid),%	0	0.1	0	0.02	0
Purity	99.7	97.8[a]		99.8[b]	99.9
Sodium content, %					6.6×10^{-4}
Insoluble matter, %			0.042		0.01
Acetone insolubles, %	0.03	0.006		0.01	
Inorganic insolubles, %		0.004		0.03	
Nitrogen, %	17.7				
Vacuum stability test, mL 373 K (100°C) 40 h/5g	0.23	0.26	0.36	0.25	0.04

[a]contains 2.2% RDX
[b]contains 0.2% HMX

Table 6. Time to explosion temperatures of NATO round-robin explosives

	PETN	HMX	Tetryl	RDX	TNT
1 sec	562 K	614 K	564 K	577 K	776 K
	289°C	341°C	291°C	304°C	503°C
5 sec	496 K	560 K	507 K	521 K	473 K
	223°C	287°C	234°C	248°C	400°C
5 sec (ref 4)	501 K	573 K	516 K	534 K	669 K
	228°C	300°C	243°C	261°C	396°C

Explosion temperature ranking

PETN
Tetryl
RDX
HMX
TNT

Table 7. Thermoanalytical characterization of NATO round-robin explosives

Summary

Material	Atmosphere	TGA, start of decomp. or volatization*, K (°C)	TGA, 10° sample weight loss, K (°C)	DTA, endo, K (°C) start	DTA, endo, K (°C) peak	DTA, exo, K (°C) start	DTA, exo, K (°C) peak	Notes K (°C)
TNT	Air	370 (97°)	443 (170°)	348 (75°)	352 (79°)	501 (228°)	513 (240°)	Broad region, 370-643 (97-370°)
TNT	N_2	379 (106°)	450 (177°)	351 (78°)	353 (80°)	523 (250°)	523 (252°)	Broad region, 378-643 (105-370°)
PETN	Air	405 (132°)	448 (175°)	405 (132°)	411 (138°)	433 (160°)	463 (190°)	
PETN	N_2	405 (132°)	448 (175°)	405 (132°)	413 (140°)	435 (162°)	468 (195°)	
Tetryl	Air	403 (130°)	468 (195°)	393 (120°)	398 (125°)	450 (177°) 605 (332)	478 (205°) 631 358°)	Complex thermogram See curve
Tetryl	Air	447 (174°)	468 (195°)	395 (122°)	400 (127°)	453 (180°) 613 (340°)	480 (270°) 636 (363°)	"
HMX	Air	460 (187°)	550 (277°)	455 (182°)	460 (187°)	543 (270°)	553 (280°)	
HMX	N_2	466 (193°)	546 (273°)	453 (180°)	458 (185°)	538 (265°)	551 (278°)	
RDX	Air	435 (162°)	488 (215°)	468 (195°)	473 (200°)	475 (202°)	513 (240°)	Mild exo peak at 603 (330°)
RDX	N_2	436 (163°)	486 (213°)	465 (192°)	473 (200°)	475 (202°)	508 (235°)	Mild exo peak at 650 (337°)

* Values are approximate, based on subjective interpretation.

Note:
1. Sea level pressure of atmosphere
2. Heating rate 10K/min
3. Prior to trial, sample held in vacuum over at 335K (60°C) ± 25 in. (pull) for minimum of six hours.

Table 8. DSC results of NATO round-robin explosives

Perkin-Elmer DSC-1, 10°C/min
(lid crimped on sample)

Explosive	M.P.		Rapid decomposition (peak)	
	K	°C	K	°C
PETN	414	141	475	202
Tetryl	403	130	479	206 (detonated)
RDX	483	210	500	227 (detonated)
HMX		-	551	278 (detonated)
TNT	346	73	606	333

Table 9. Particle size distribution (sieve method)

Sieve	(mm size)	Percent retained				
		PETN	HMX	Tetryl	RDX	TNT
# 30	(0.59)	0.9	21.9	90.3	0.4	61.0
# 80	(0.177)	98.0	77.0	9.7	94.1	29.8
#100	(0.149)	0.7	0.8		3.9	3.9
#140	(0.105)	0.3	0.2		1.1	4.8
#200	(0.074	0.1	0.1		0.5	0.5

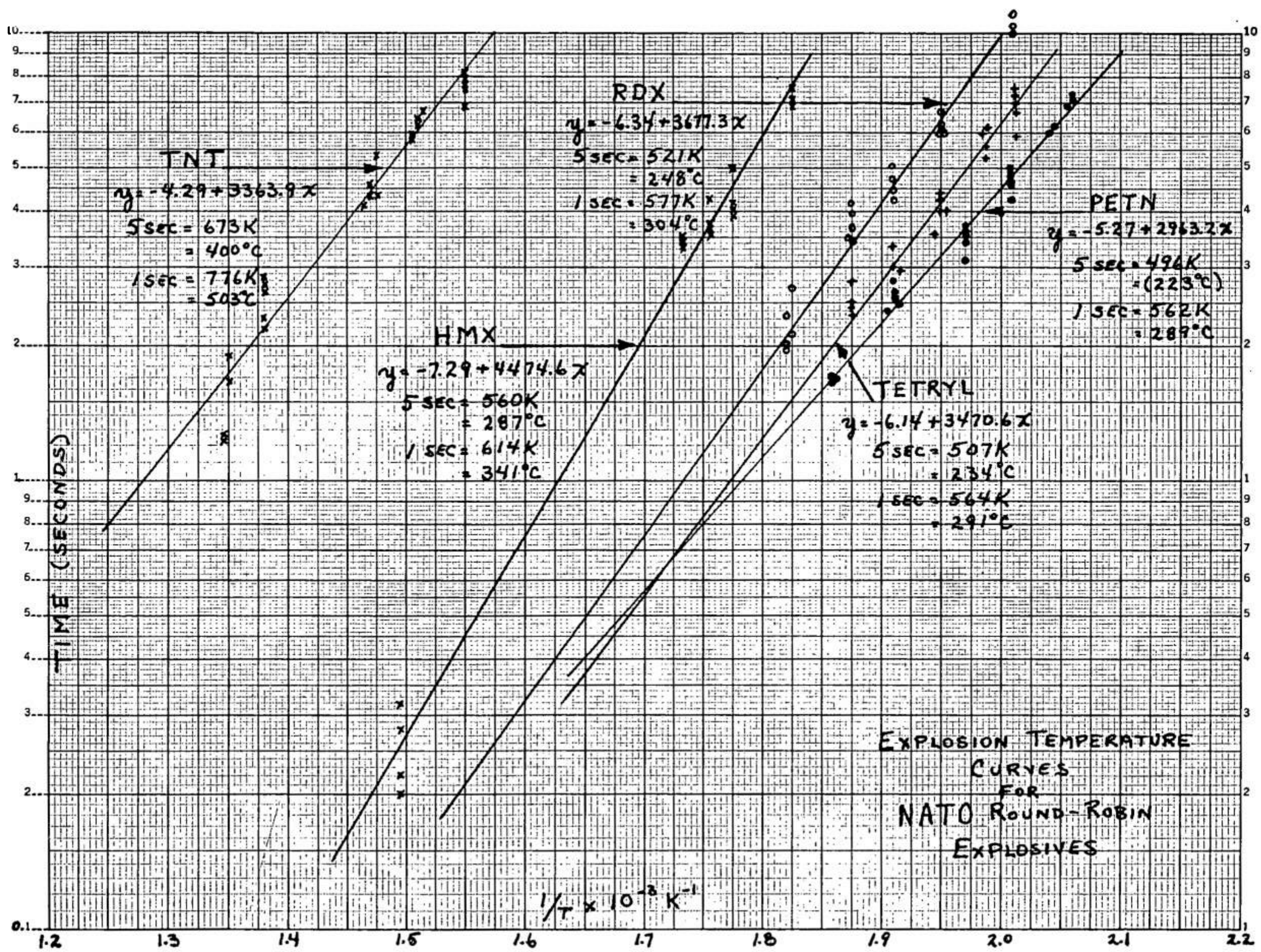

Figure 1. Explosion temperature curves for NATO round-robin explosives

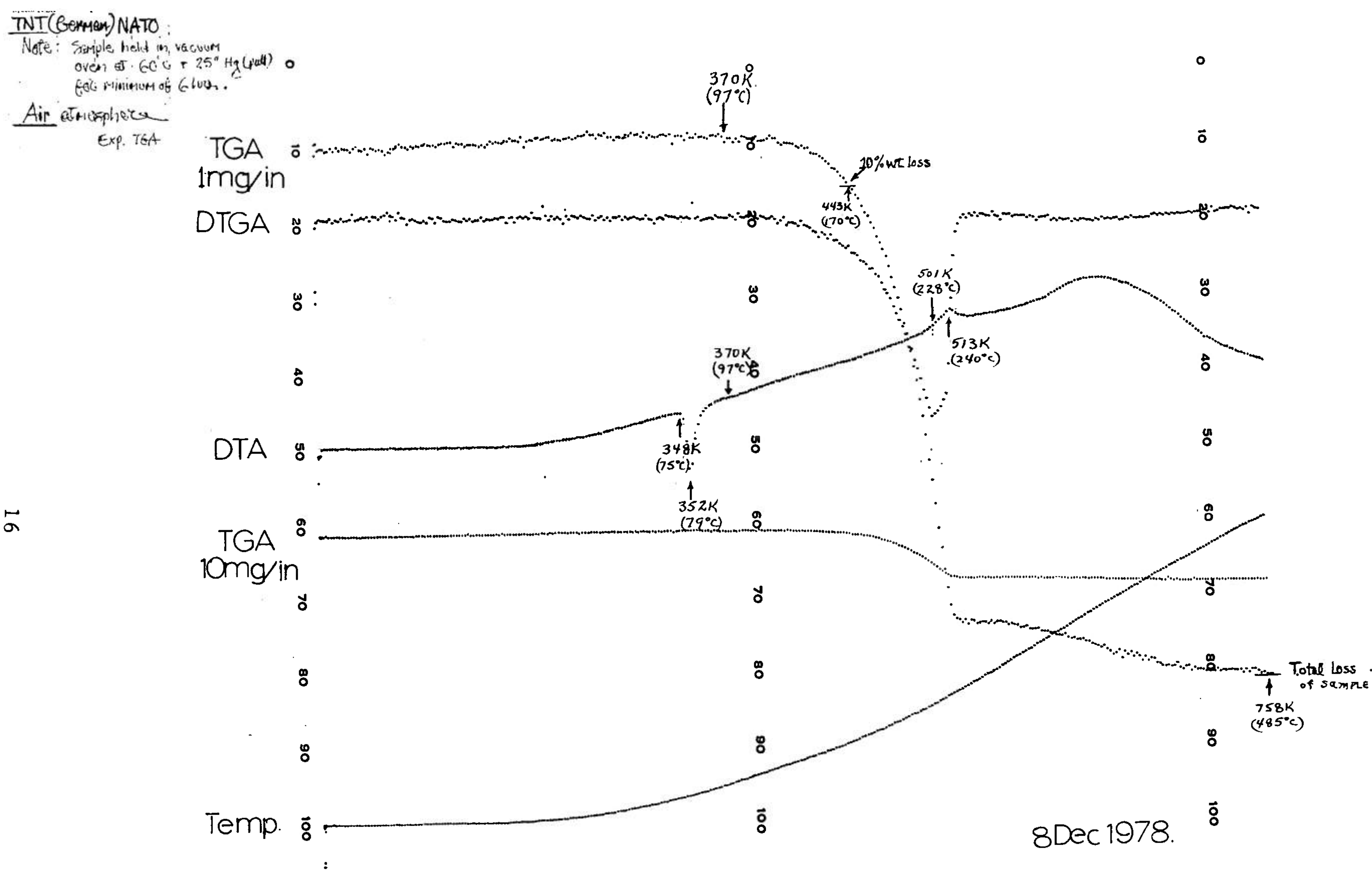

Figure 2. DTA/TGA thermogram of TNT (in air)

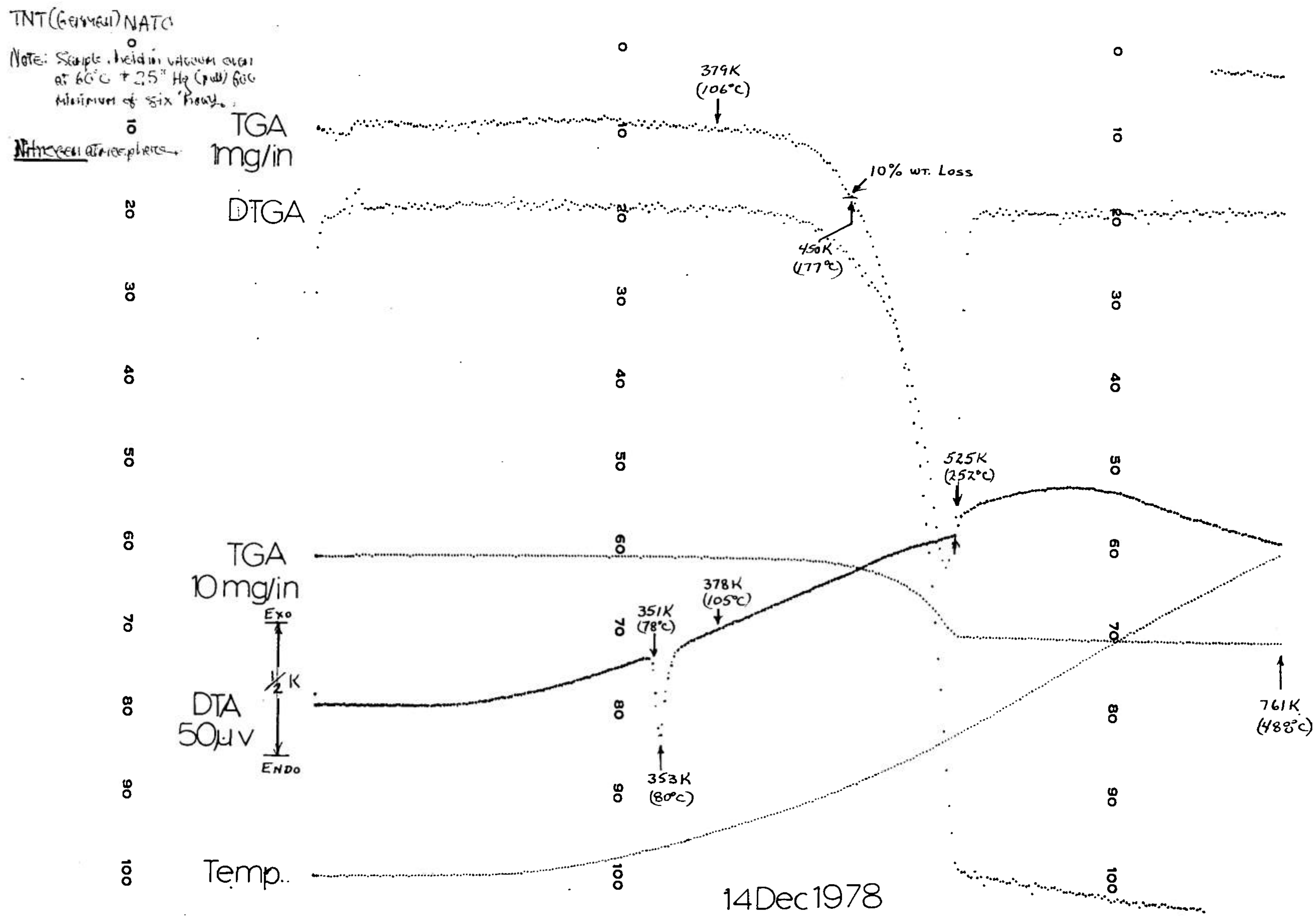

Figure 3. DTA/TGA thermogram of TNT (in nitrogen)

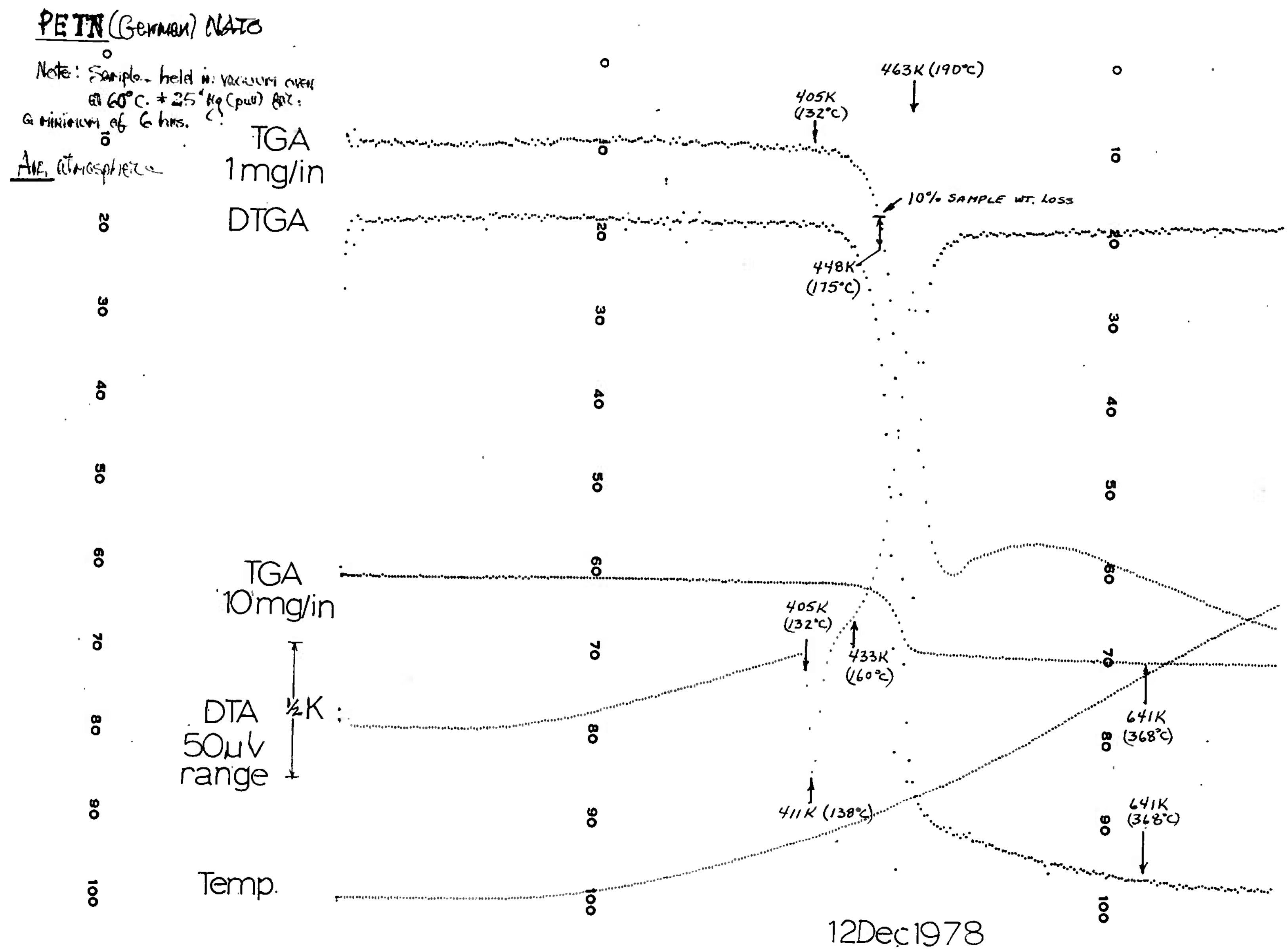

Figure 4. DTA/TGA thermogram of PETN (in air)

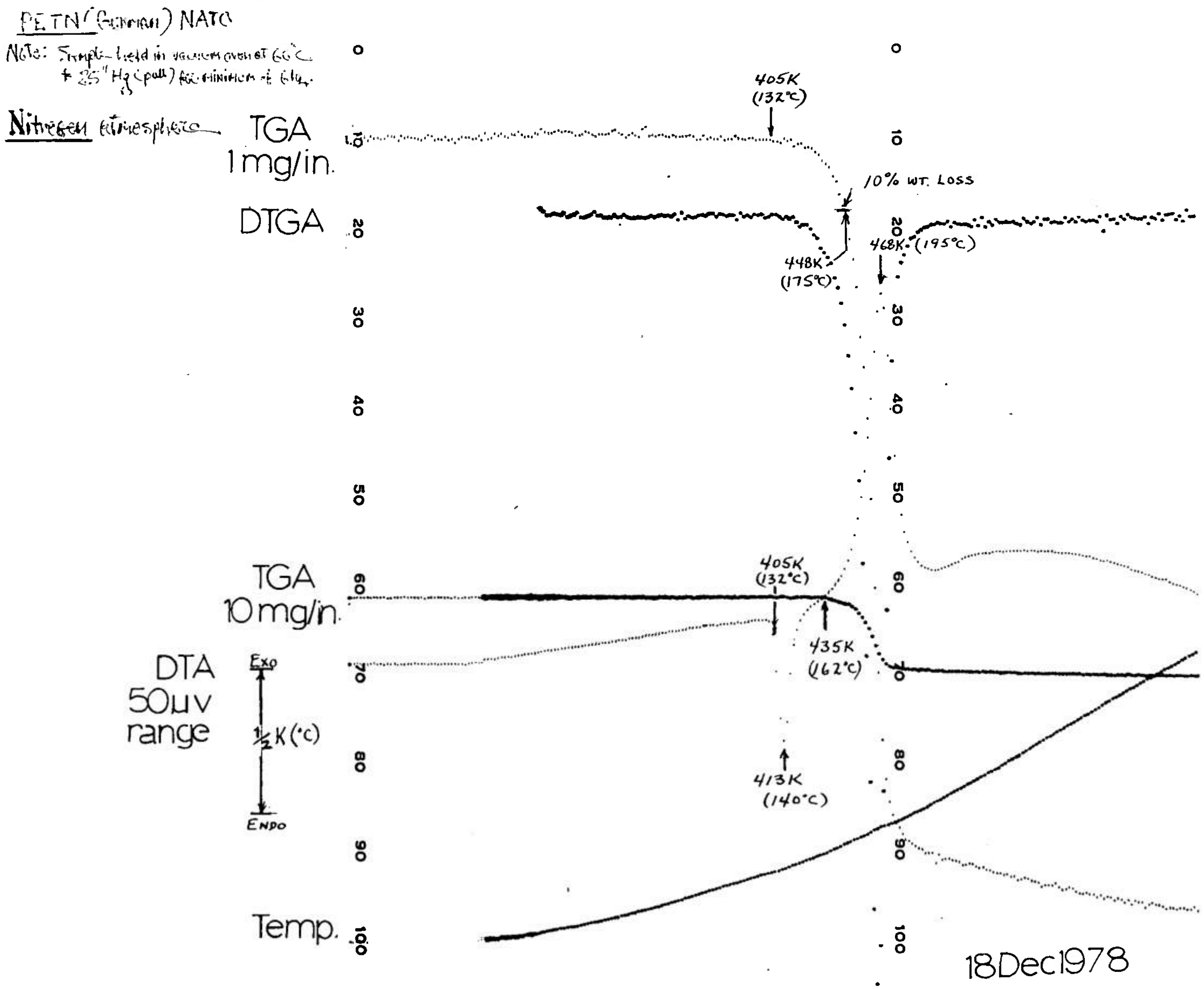

Figure 5. DTA/TGA thermogram of PETN (in nitrogen)

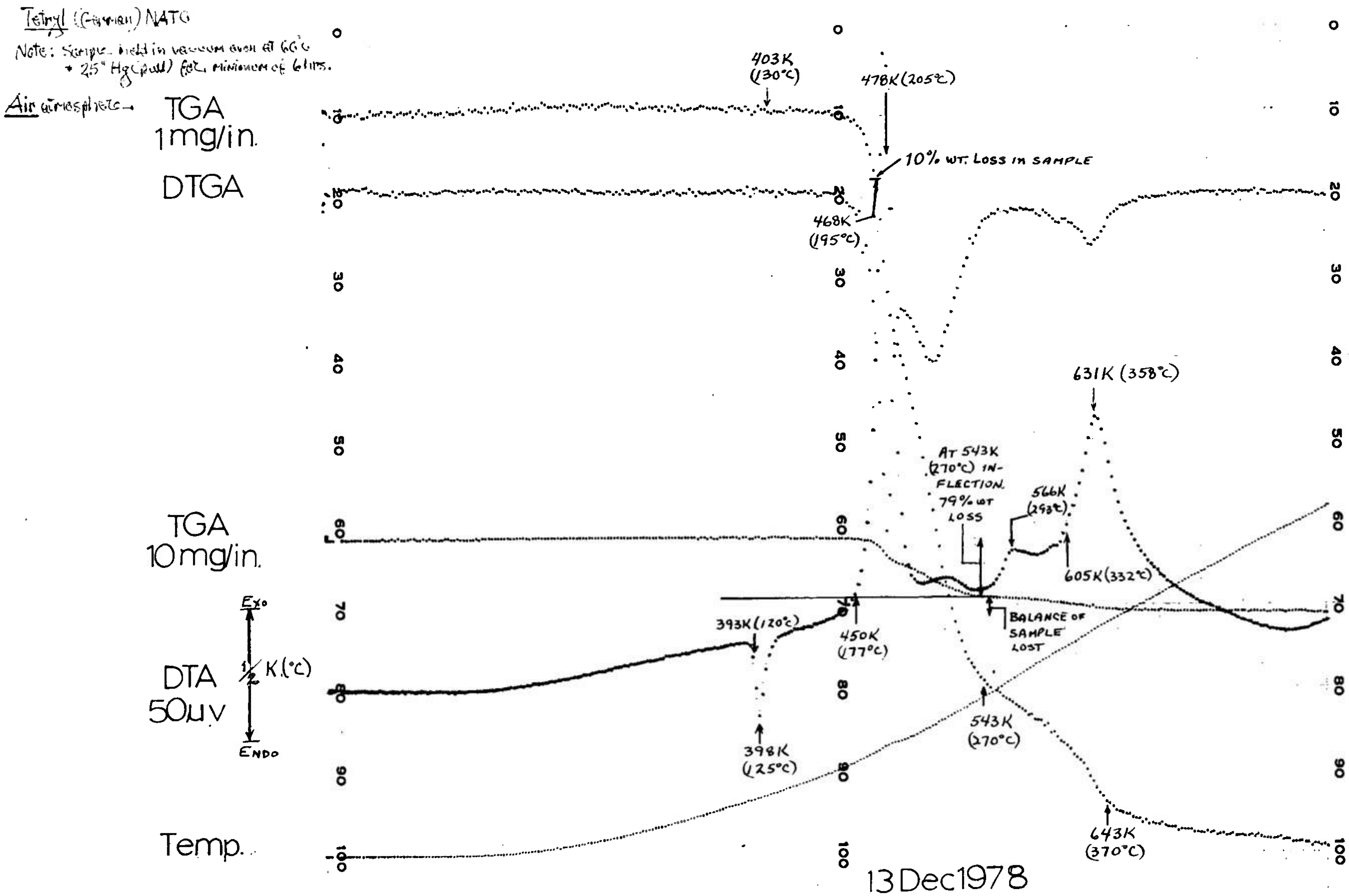

Figure 6. DTA/TGA thermogram of tetryl (in air)

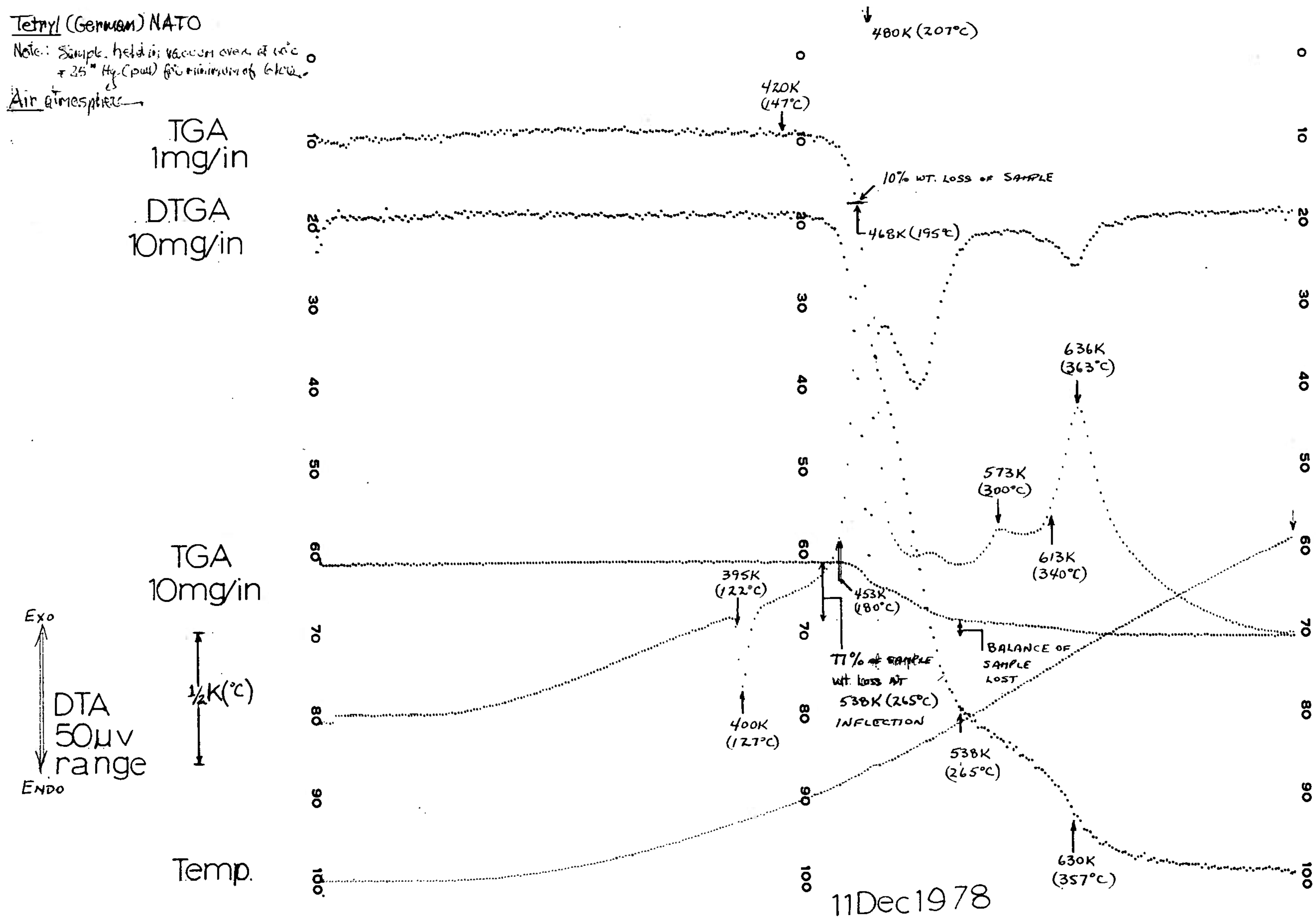

Figure 7. DTA/TGA thermogram of tetryl (in air) (2nd run)

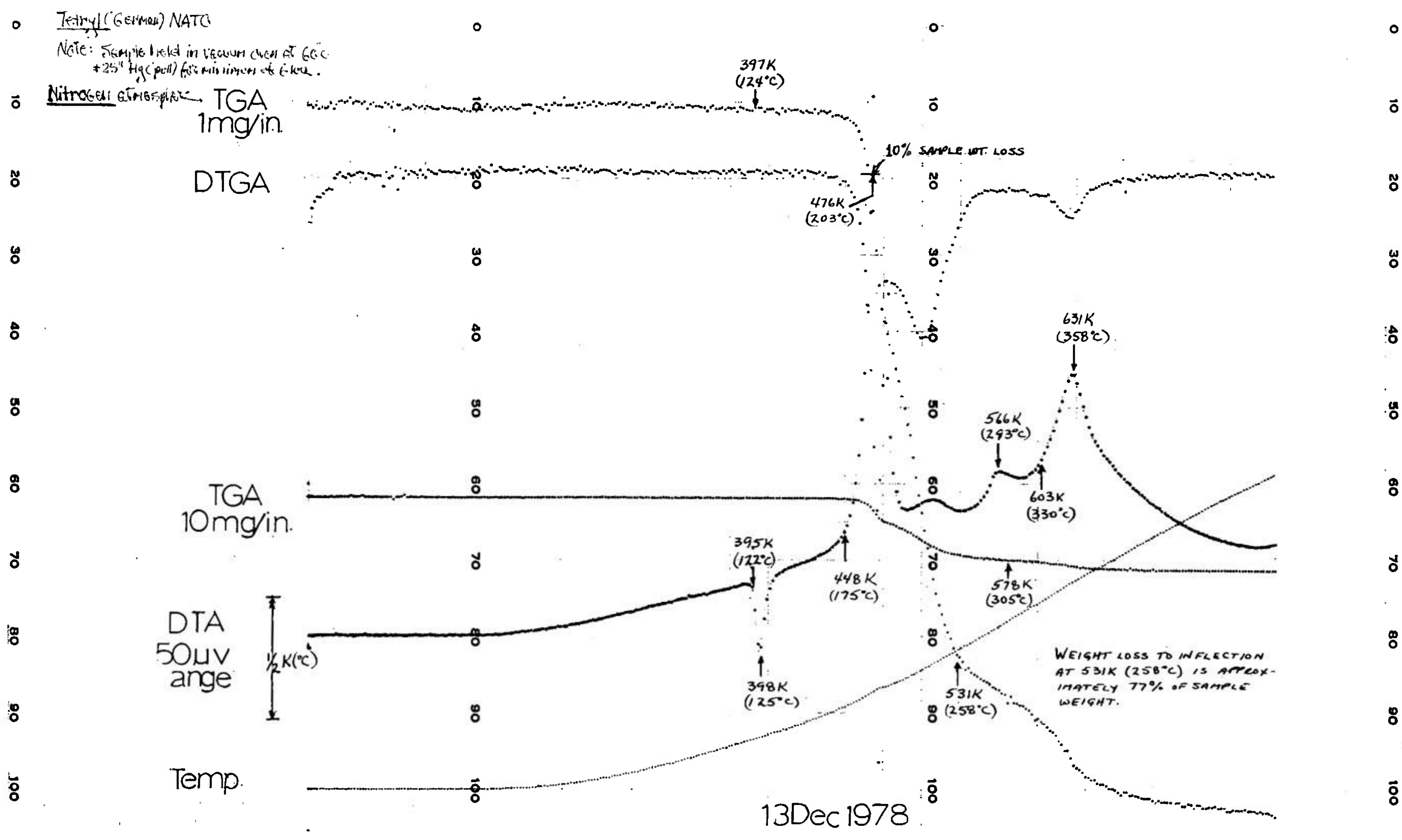

Figure 8. DTA/TGA thermogram of tetryl (in nitrogen)

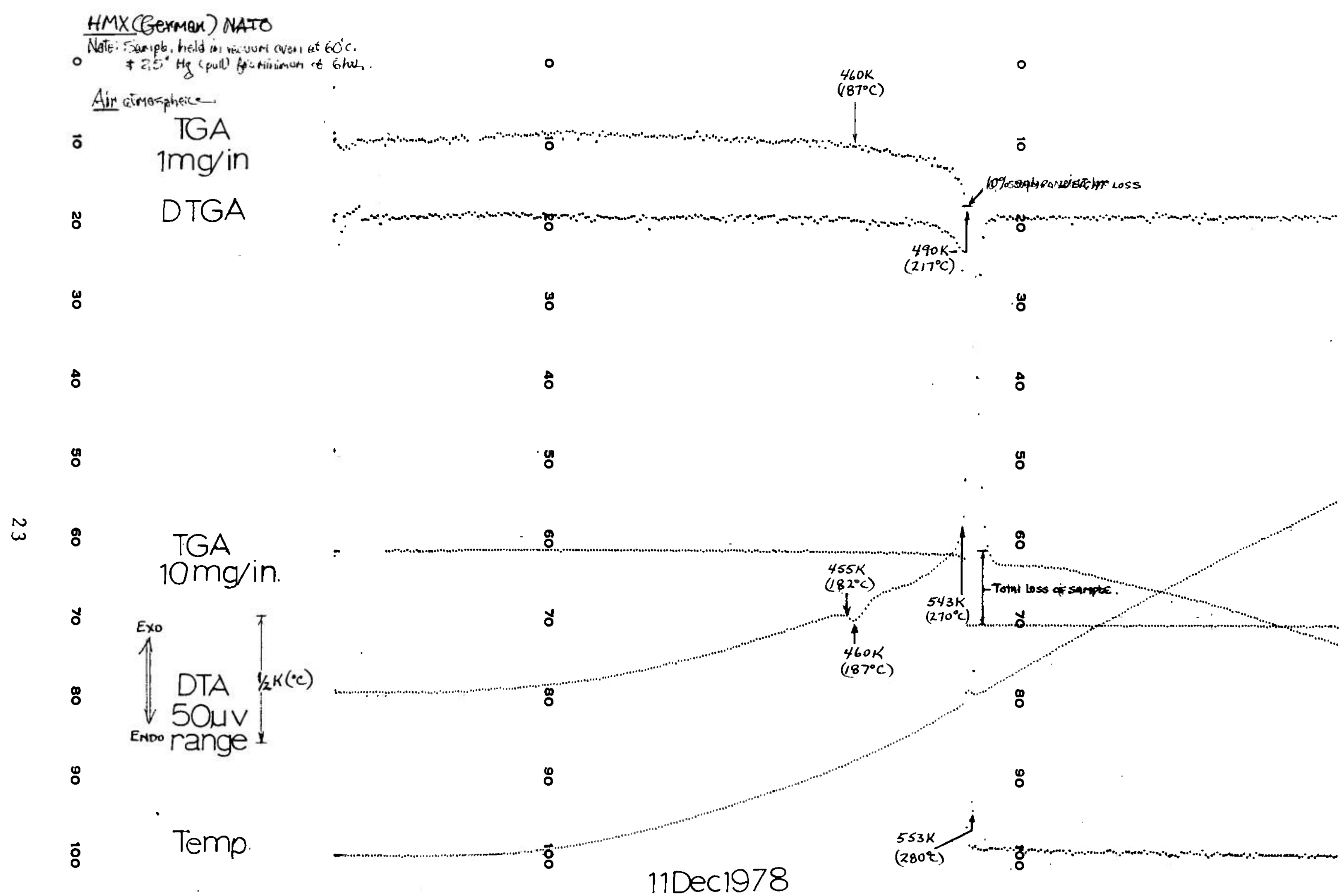

Figure 9. DTA/TGA thermogram of HMX (in air)

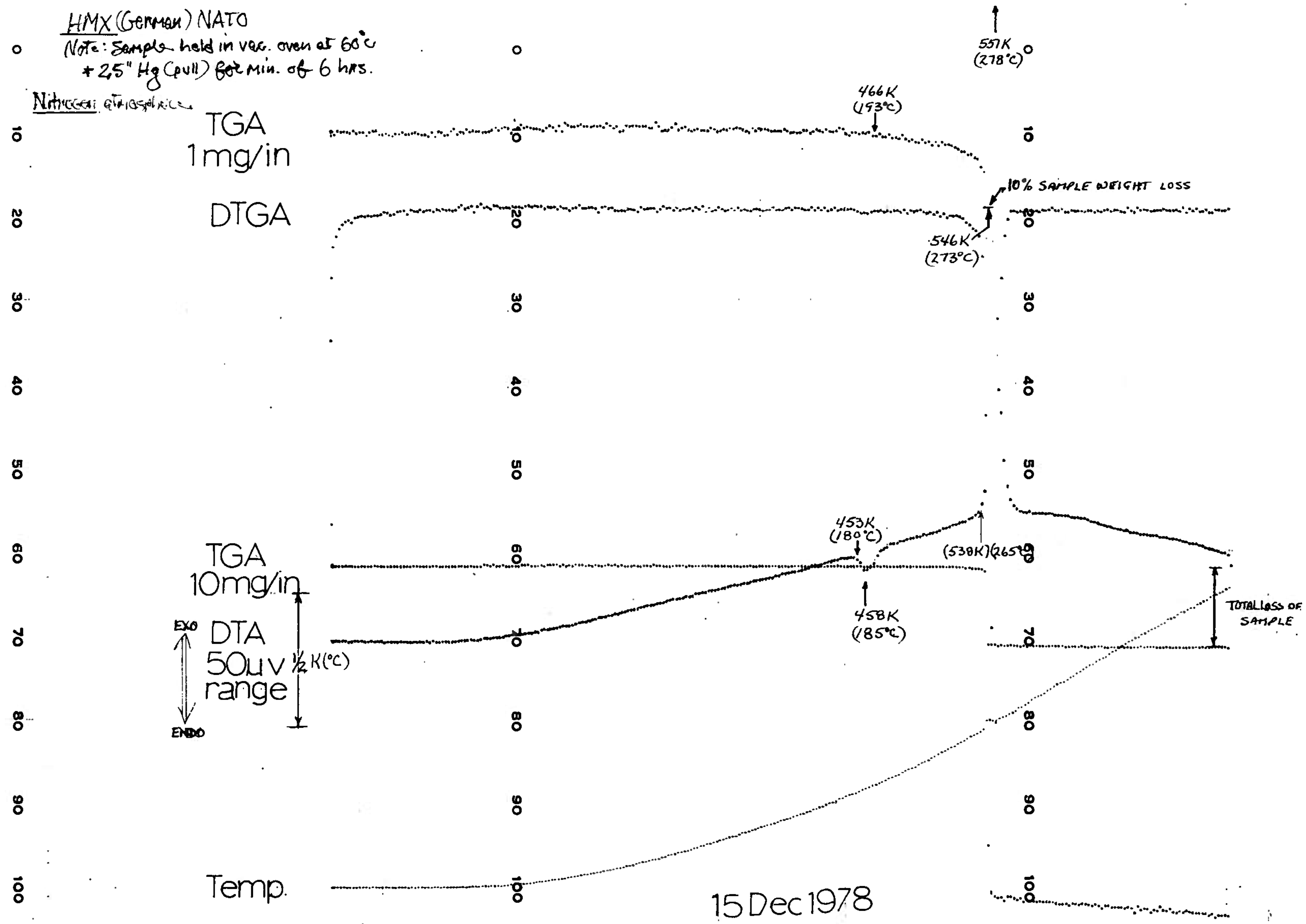

Figure 10. DTA/TGA thermogram of HMX (in nitrogen)

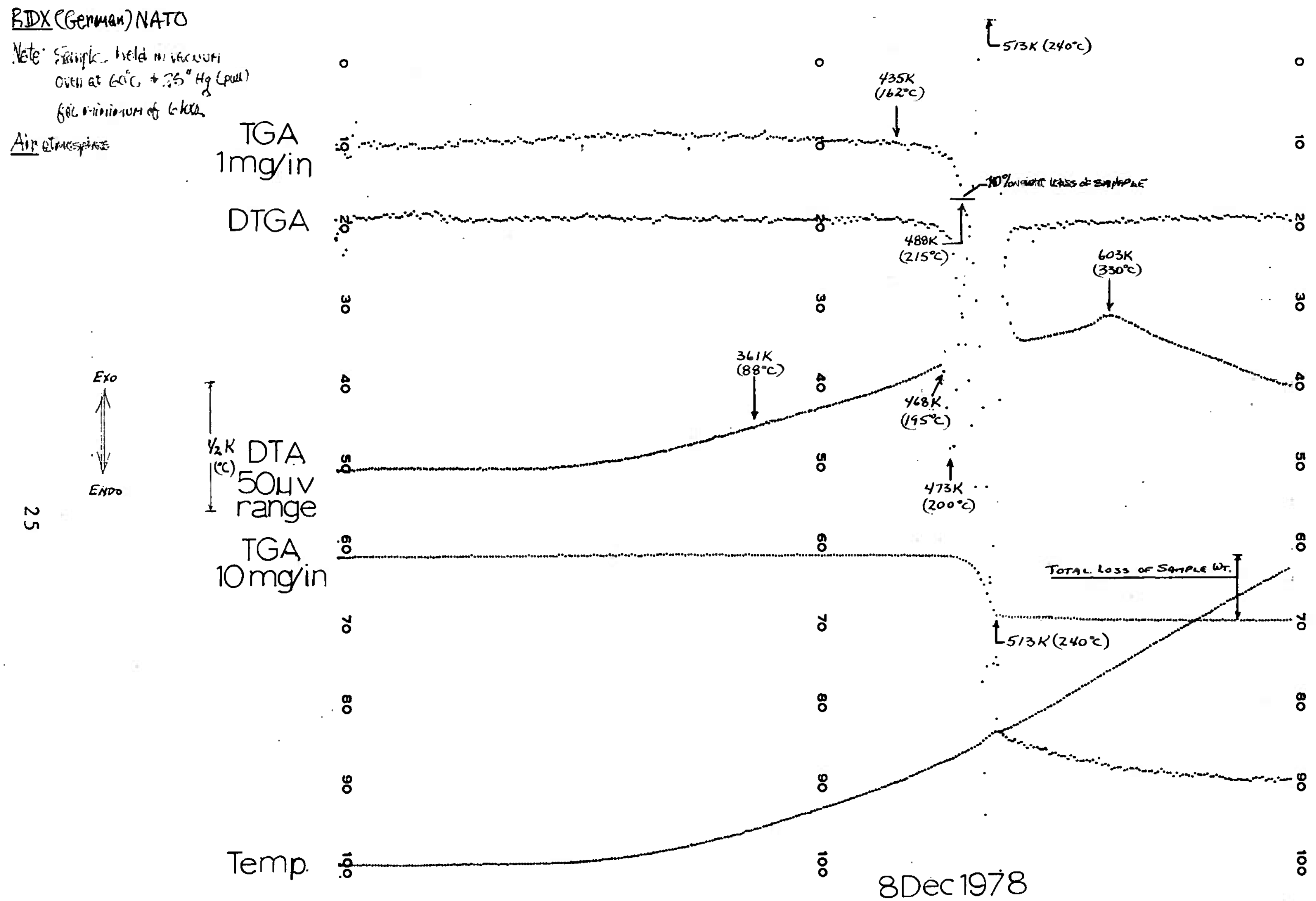

Figure 11. DTA/TGA thermogram of RDX (in air)

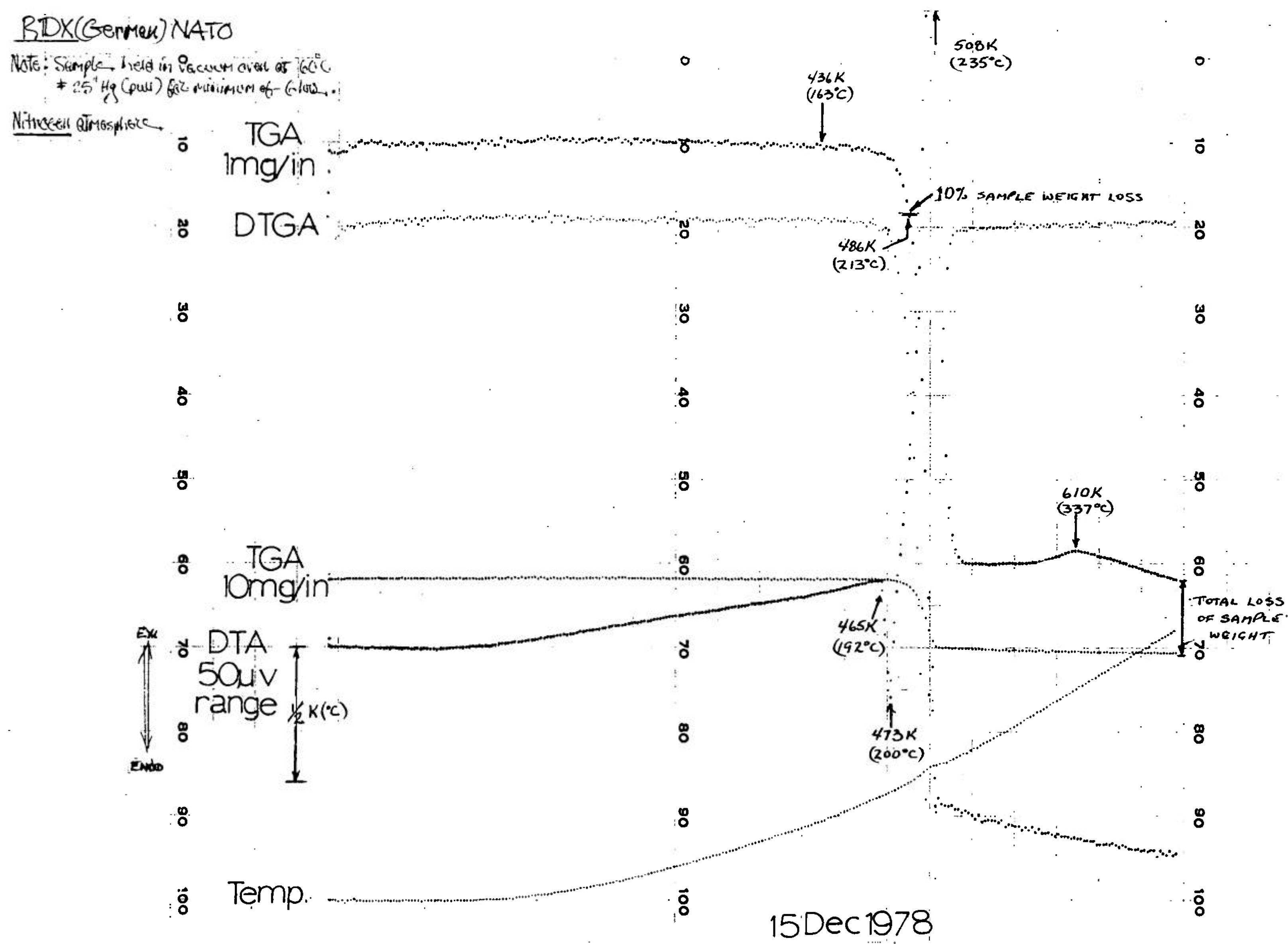

Figure 12. DTA/TGA thermogram of RDX (in nitrogen)

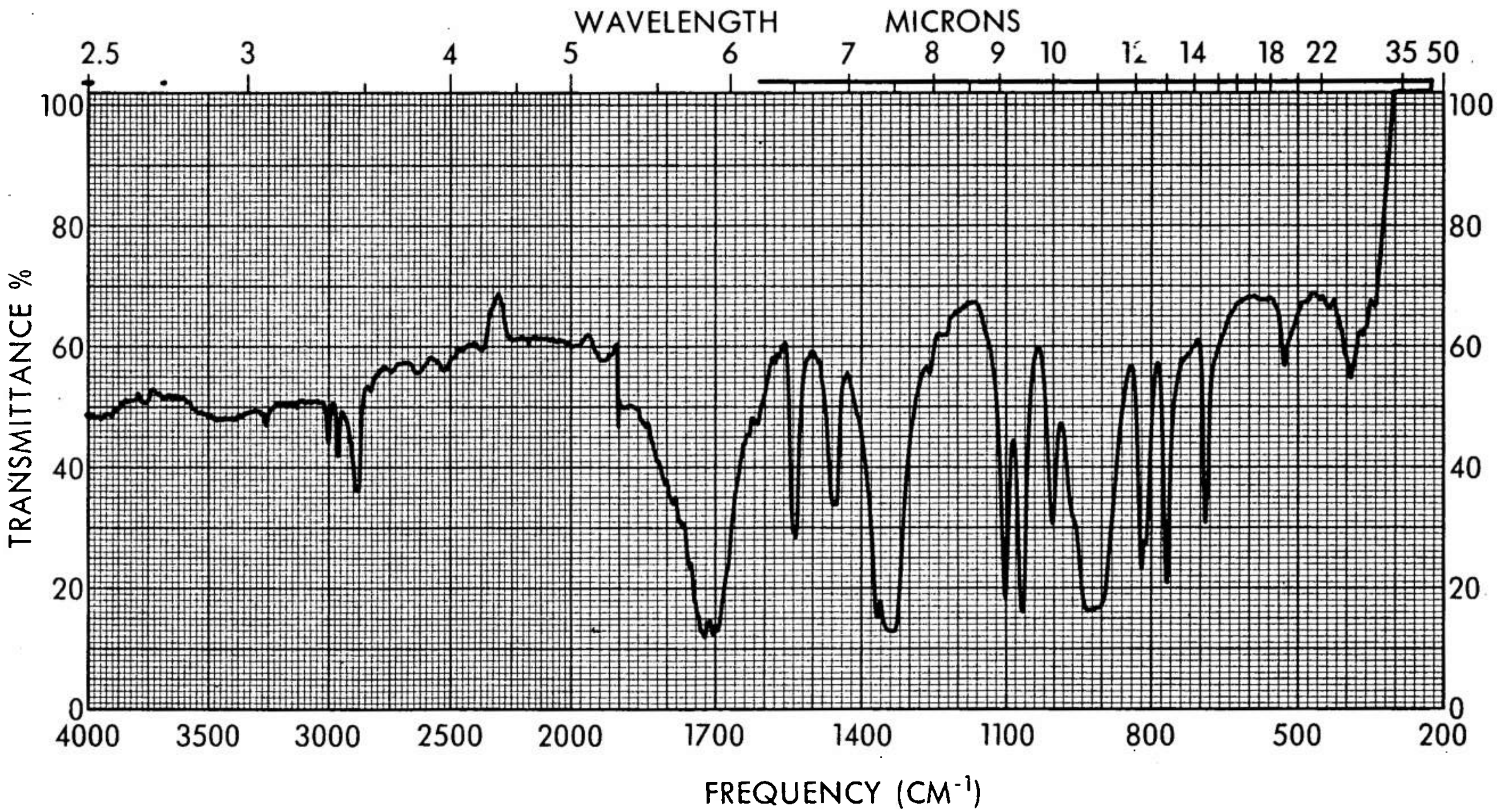

Figure 13. IR spectra of PETN

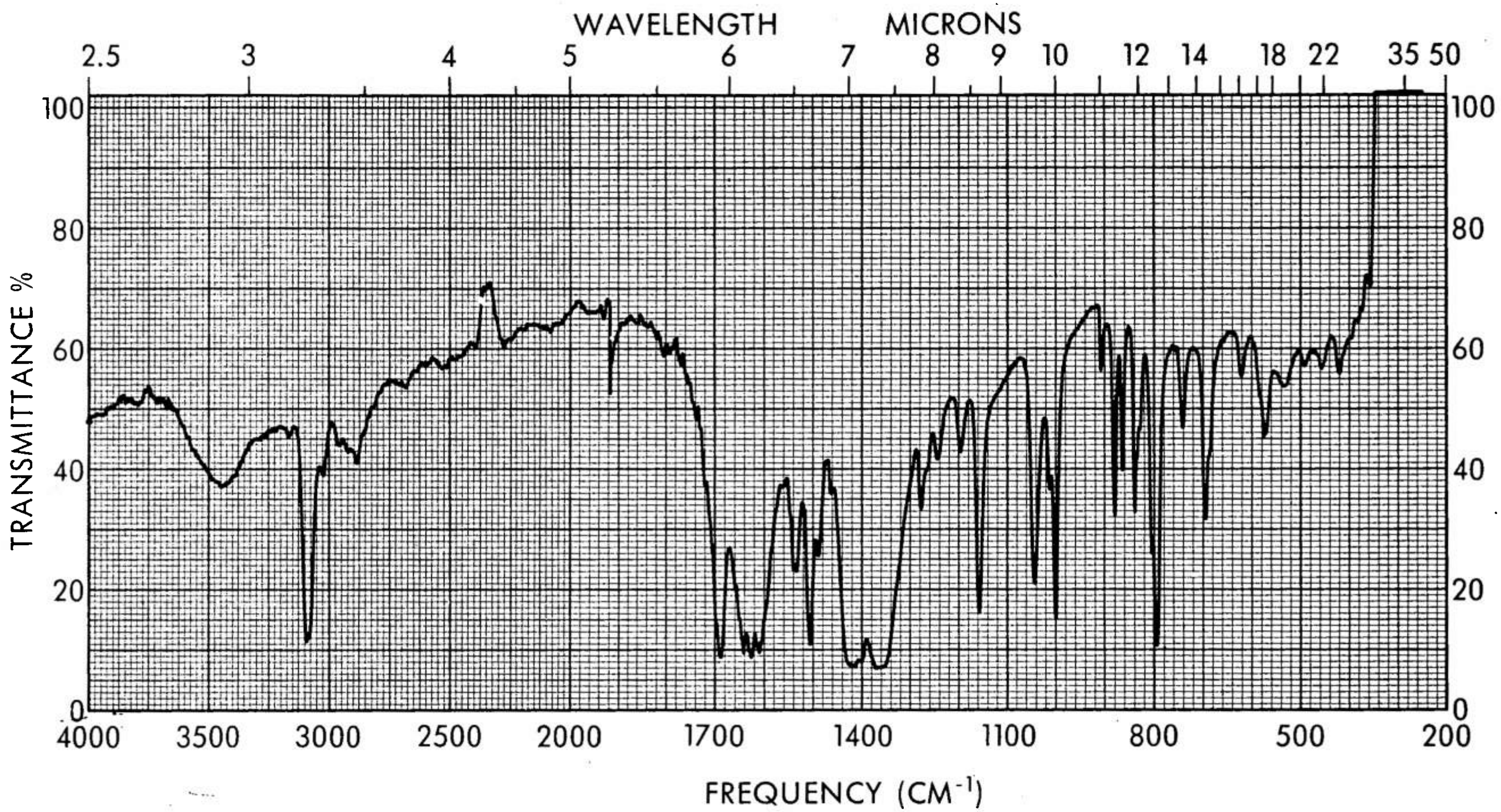

Figure 14. IR spectra of HMX

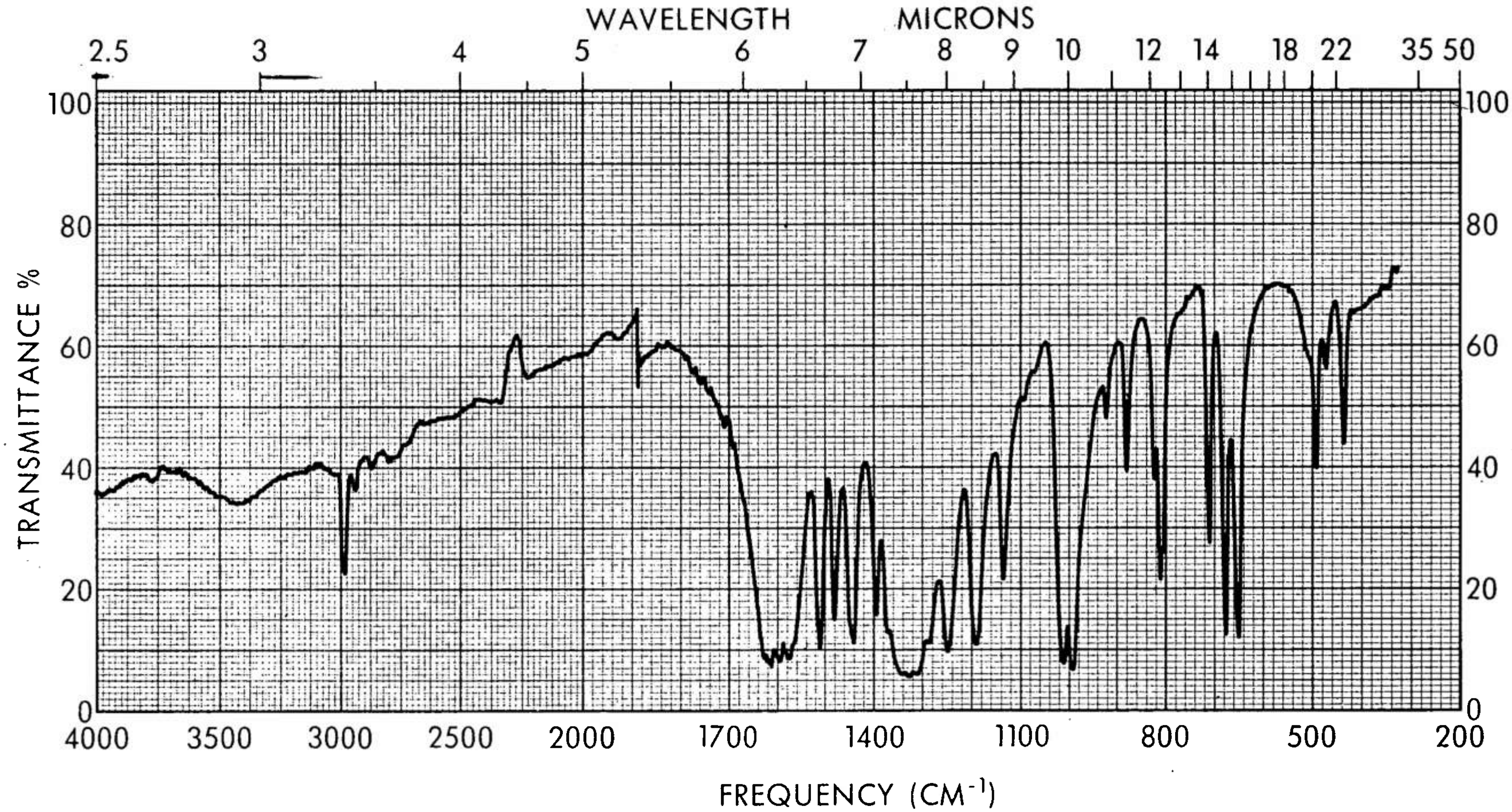

Figure 15. IR spectra of tetryl

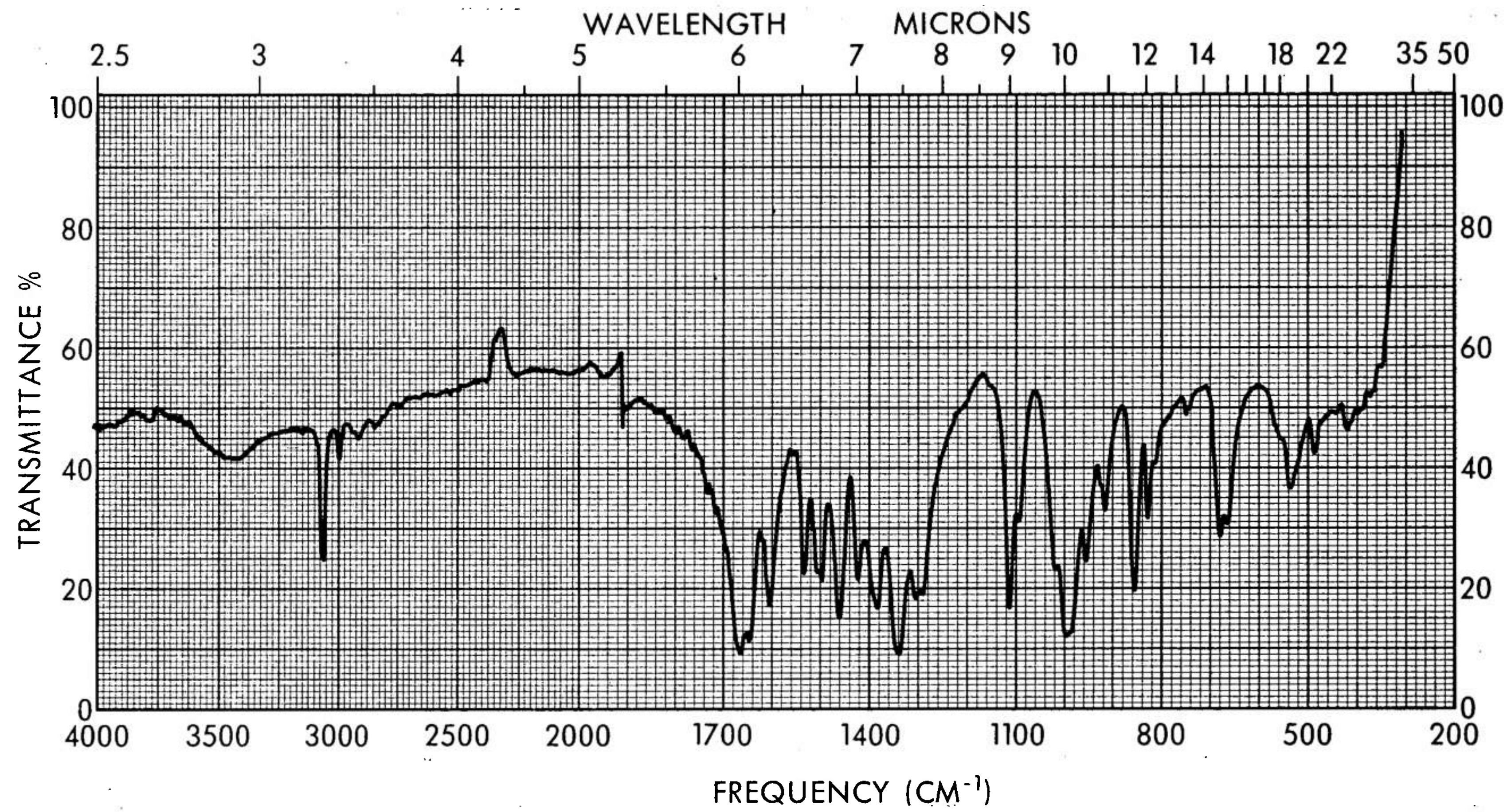

Figure 16. IR spectra of RDX

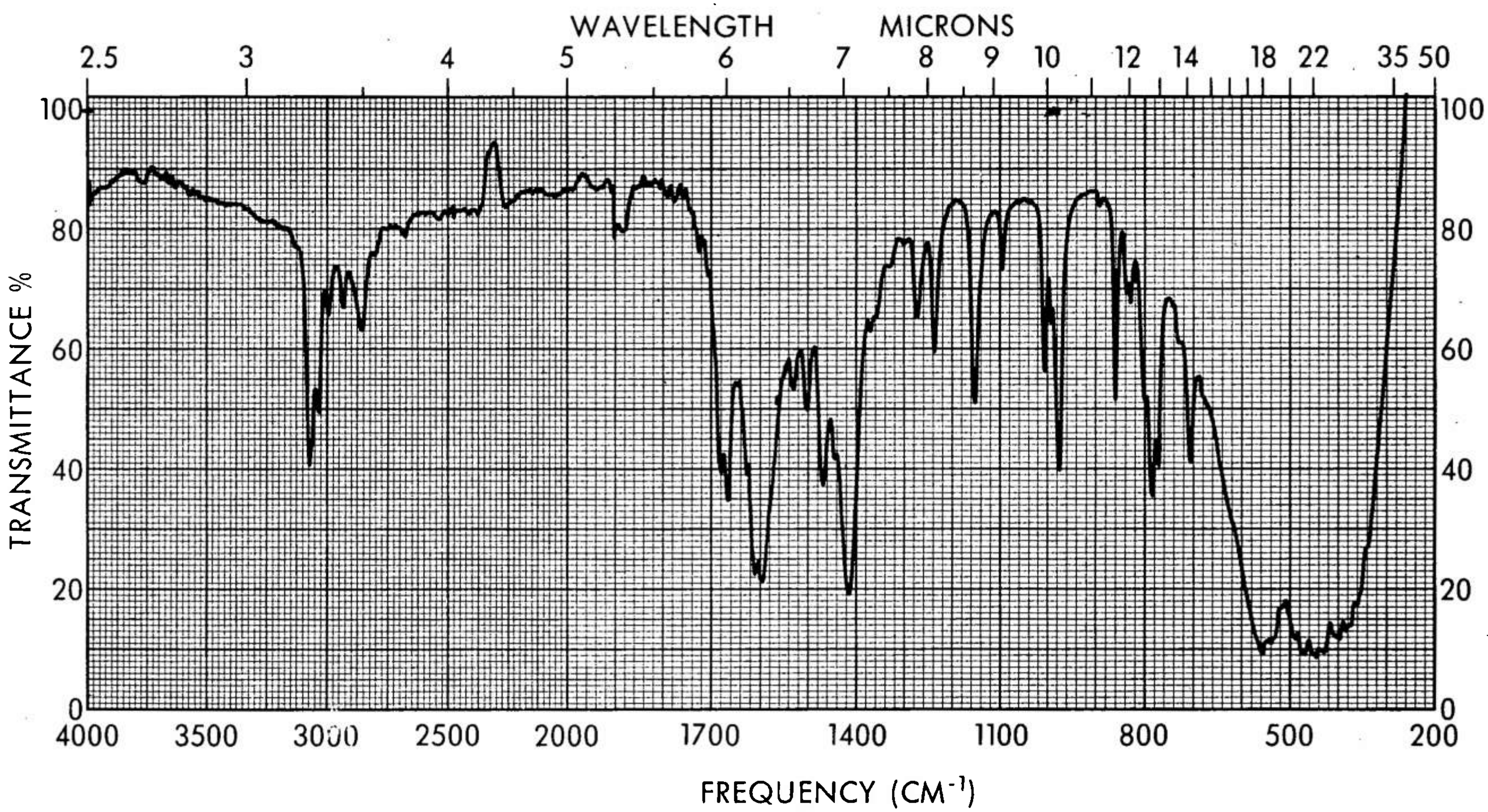

Figure 17. IR spectra of TNT

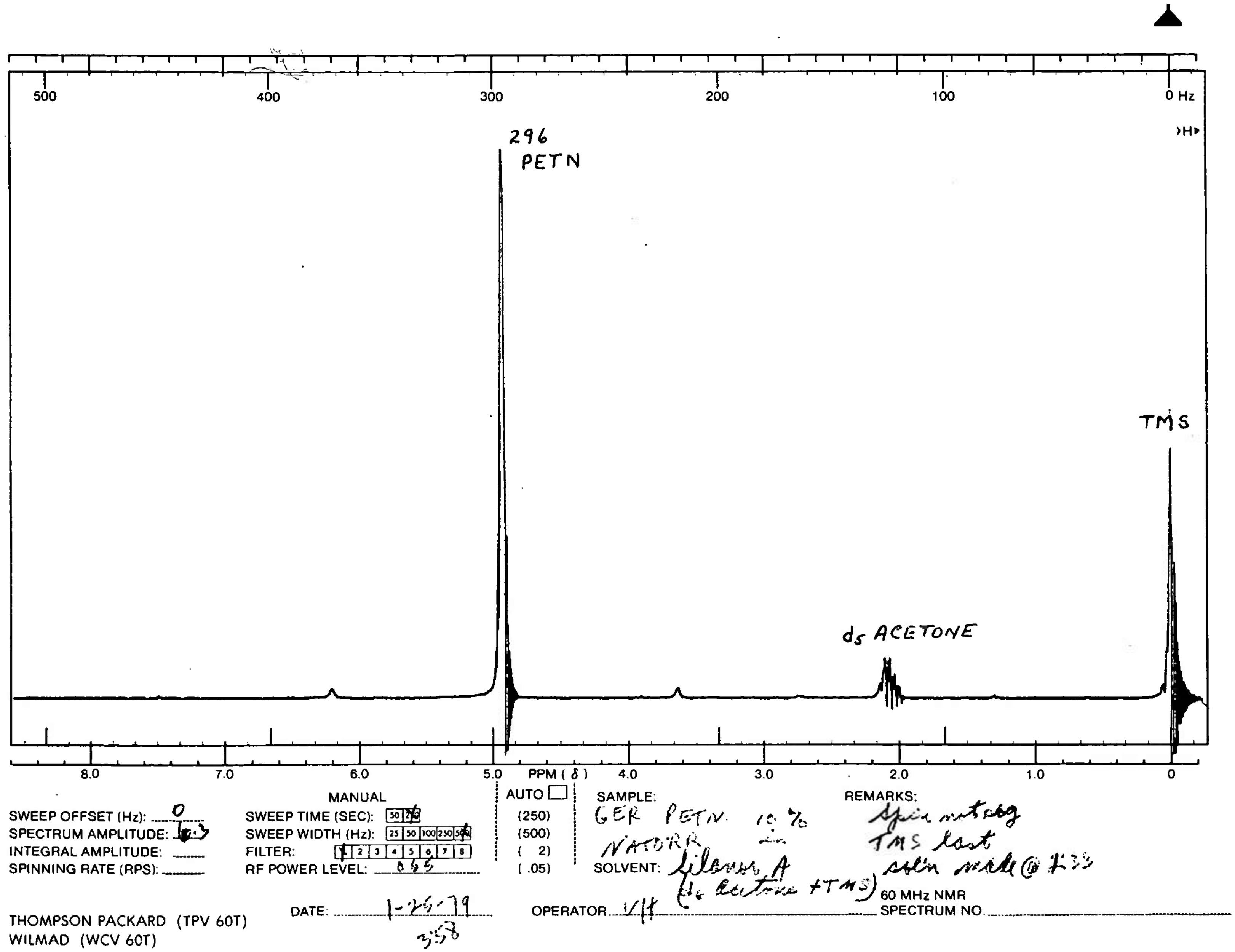

Figure 18. NMR spectra of PETN

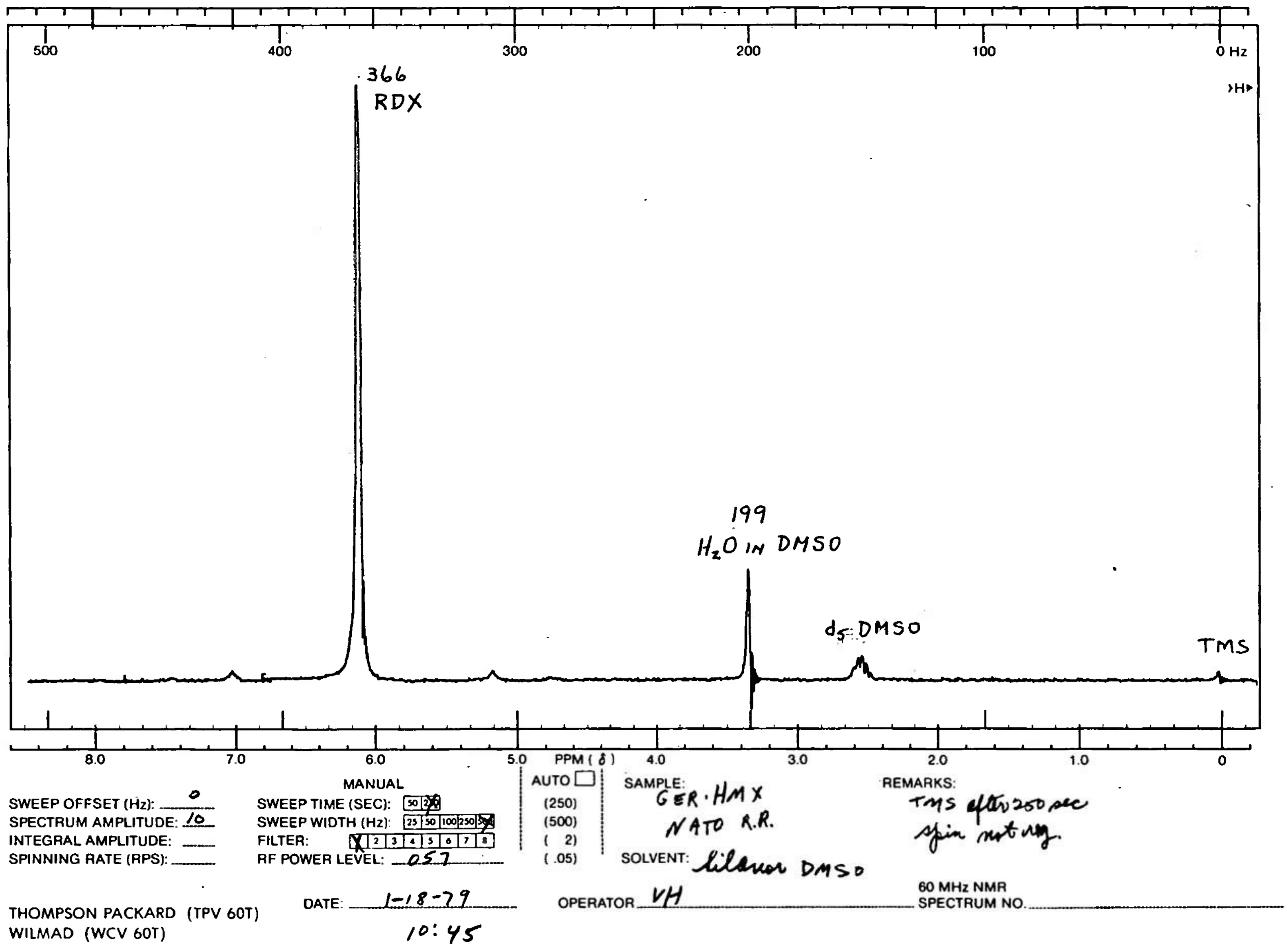

Figure 19. NMR spectra of HMX

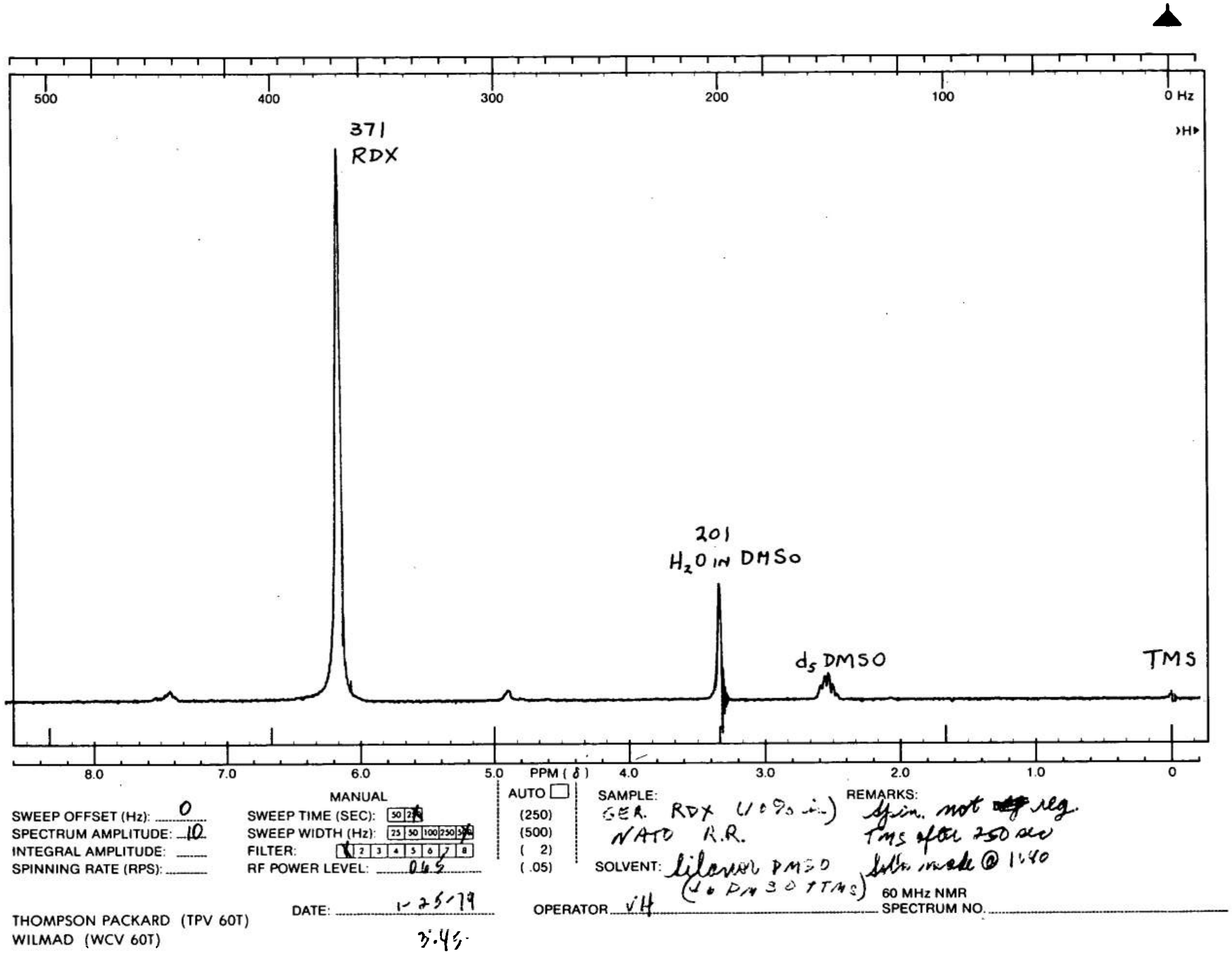

Figure 20. NMR spectra of RDX

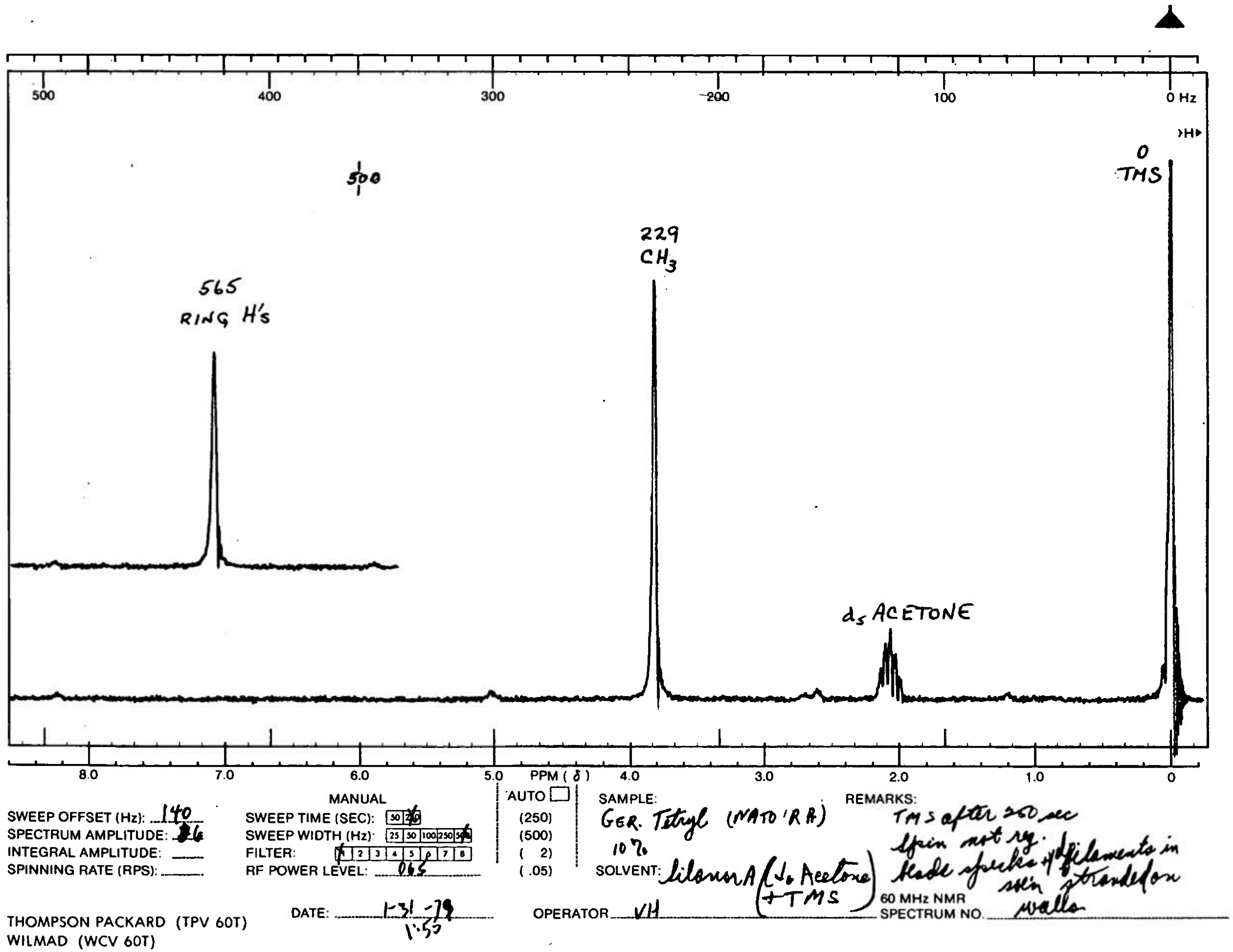

Figure 21. NMR spectra of tetryl

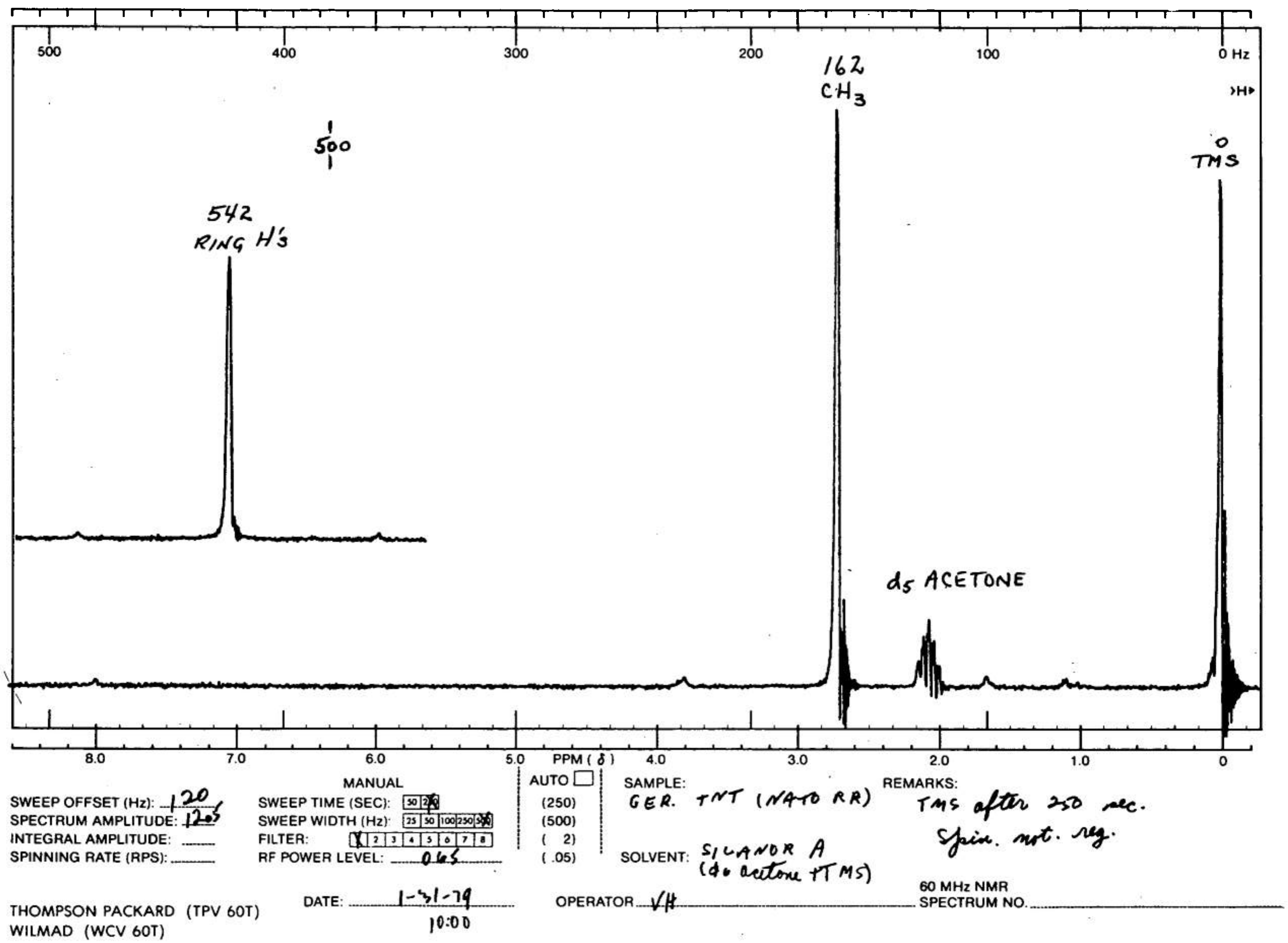

Figure 22. NMR spectra of TNT

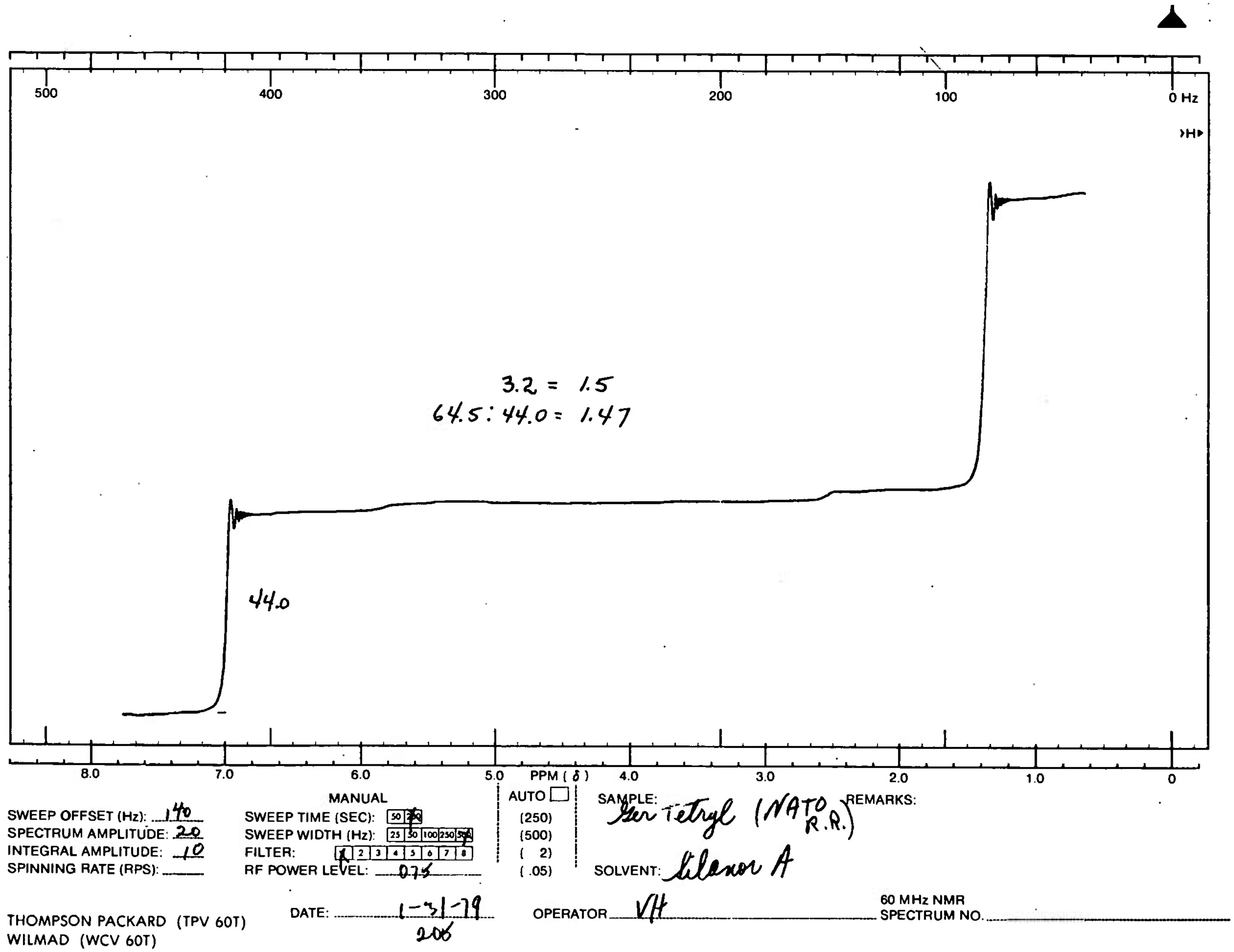

Figure 23. Integral of NMR spectra of tetryl

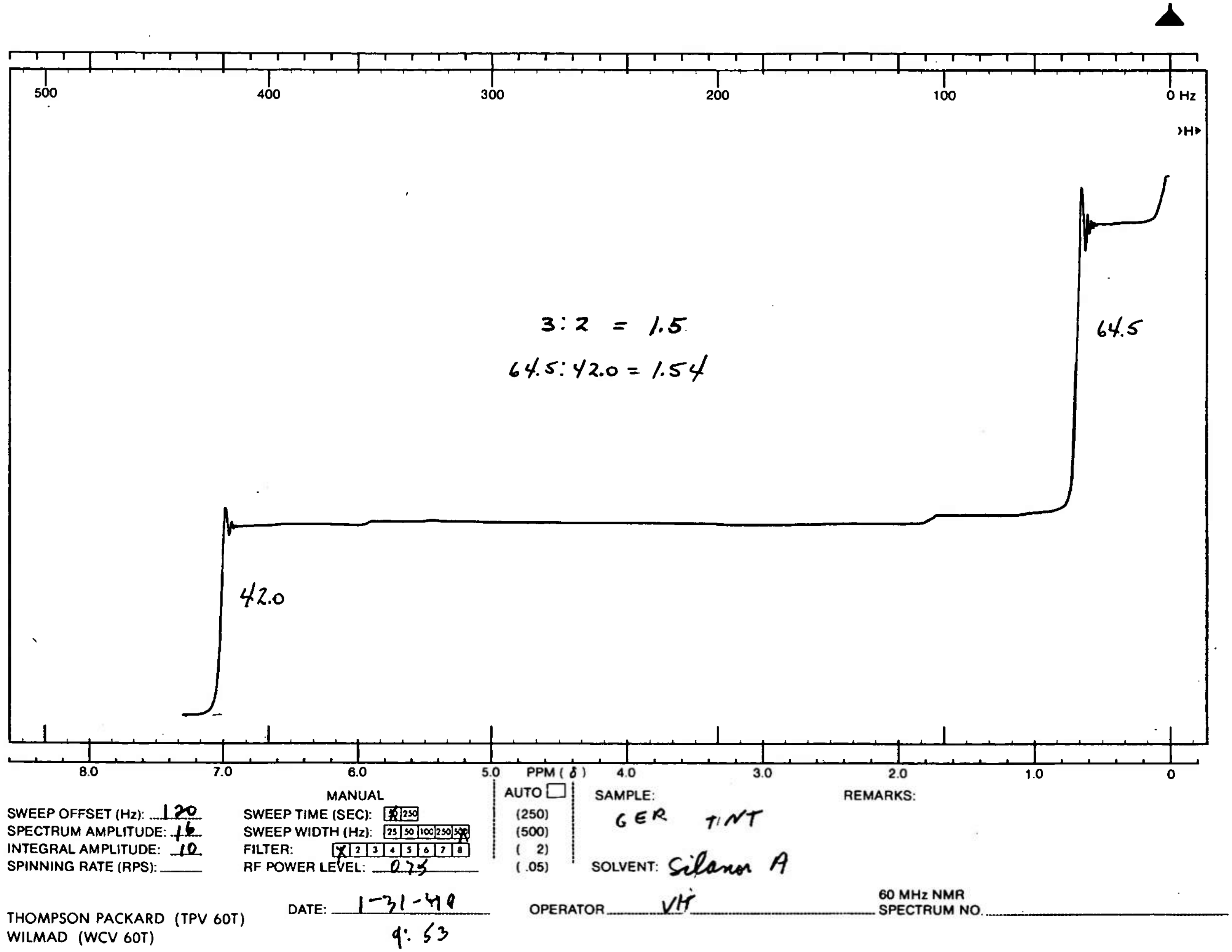

Figure 24. Integral of NMR spectra of TNT

APPENDIX

SAMPLES OF HIGH EXPLOSIVES SELECTED FOR A NATO ROUND-ROBIN TEST

Bundesinstitut
für chemisch-technische
Untersuchungen (BICT)

5357 Swisttal, 7.4.1978
Heimerzheim
Fernsprecher: (02222) 40 81
Fernschreiber: 8 869 318 cli d
Postanschrift: Postfach 17 02 60
5300 Bonn 1

Samples of High-Explosives selected for a NATO-Round-Robin Test

The for the NATO, for explosives competent gremium, AC/225, subpanel IV 2, was asked by the Air Armaments Working Party (AAWP) to develop and standarize methods for characterizing the sensitiveness of explosives for lead- and booster charges, and to define the sensitiveness limits of STANAG 3525 (see also AC/225, panel IV, D/77).

To accomplish this task, the subpanel IV 2 arranged a Round-Robin Test, where the participating nations were to ascertain, with their usual test equipment and methods, the sensitiveness of identical high explosives.
As typical explosives TNT, HMX, RDX, Tetryl and PETN were selected for these investigations.

The BICT supplied countries, willing to participate on the Round-Robin Test, with 1 kg each of above mentioned explosives and provided following places with samples:

BELGIUM	260 Cie Mun.; Camp Reine Astrid 518 Probsteierwald über Eschweiler, RFA
FRANCE	Etablissement technique de Bourges - Division de Contrôle Pyrotechnique - 18015 Bourges
NETHERLANDS	Technologisch Laboratorium TNO Prins Maurits Laboratoria Rijswijk (Z.H.) -2100, Lange Kleiweg 137
UNITED KINGDOM	Procurement Executive Ministery of Defence, PERME Waltham Abbey, Essex EN 9 1BP, Powdermill Lane

UNITED STATES ARRADCOM - DRDAR
Large Caliber Weapon Systems Laboratory
Energetic Materials Division (-LCE)
Dover, N.J. 07 801

ITALY MARIPERMAN, La Spezia

Italy on its own accord received a Tetryl-sample only.
The shipping of TNT and Tetryl took place in the state as received from the manufacturer, HMX, RDX and PETN were shipped moistened with 30 % water to comply with shipping regulations.

Prior to the tests the moist samples were dried at 50°C under vacuum until a constant weight was reached. Then the dried samples were screened through a coarse sieve (1 mm mesh) to rid them of lumps. Thus a uniform, free flowing product was obtained.

All samples should be tested without additives or further breakdown of particles.
The explosives were purchased by us since we ourselves are not in a position to produce lots of this size. Later difficulties arose, since the supplier were not able or willing to furnish the manufacturing history of the various explosives.
In the enclosures 1 to 5 you will find further details on said explosives. Moreover it will remain our endeavour to obtain details on manufacturing procedures which will be forwarded to the involved nations.

Bartels

Dr. Bartels

Anlage 1

zu 3.4-9/4510/78

TNT-Probe für Round-Robin Test

Hersteller: (Manufacturer)	Fa. Dynamit Nobel AG (W-Germany) Werk Leverkusen-Schlebusch
Probenbezeichnung: (sample symbol)	S - 1 - 32, Charge 7 vom 14.12.1972
Herstellungsverfahren: (manufacturing-process)	Chargenverfahren, Nitrierung in 3 Stufen und anschließende Reinigung des Roh-TNT durch Natriumsulfit-Wäsche (Batch-process, three-stage nitration and purification with Sodiumsulfite)
Aussehen: (appearance)	hellgelbe Schuppen, ca. 0,54 mm dick (light-yellow flakes, ca. 0,54 mm thick)
Erstarrungspunkt: (Solidification point)	80,77°C
Schmelze: (melting)	klar, ohne Bodensatz (clear, without insoluble material)
flüchtige Bestandteile: (volatile material)	< 0,01 %
Acidität: (acidity)	< 0,001 %
Alkalität: (alkalinity)	keine (none)
Benzolunlösliches: (insoluble in Benzene)	0
Glührückstand: (ash)	0
Natrium: (sodium)	< 0,001 %

- 2 -

Oxidierbare Bestandteile: (oxydable components)	2,6 - DNT	0,002 %
	2,4 - DNT	0,020 %
	3,5 - DNT	0,030 %
	γ - TNT	0,050 %
	β - TNT	0,004 %

Beim Zufügen von 0,002 n $KMnO_4$-Lösung zu einem durch Kochen mit Wasser erhaltenem Auszug keine Entfärbung in 1 h

(no decoloring of a $KMnO_4$-solution 0,002 n for 1 h after adding an extract from TNT obtained by boiling with water)

Ausseigerung: (exudation)	0,08 %
Fleck-Probe: (spot-test)	23 mm Ø
Vakuumstabilität: (Vacuum stability)	0,02 ml (2,5 g/100°C)
Verpuffungspunkt: (deflagration-point)	297°C (0,5 g; 20°C/min)

(Die Daten sind dem Prüfbericht 2.1-2/3724/75 entnommen)

HMX-Probe für Round-Robin Test

Hersteller: (manufacturer)	Fa. Soc. Nationale des Poudres et Explosifs (SNPE) Poudrerie de Sorgues, Frankreich
Probenbezeichnung: (sample symbol)	grade I classe I Nr. 122 60844 Lieferung vom 21.8.1973 (receiving date: 21th of August 1973)
Herstellungsverfahren: (manufacturing process)	keine Angaben, konnte auch anläßlich eines Besuches bei der Herstellerfirma nicht in Erfahrung gebracht werden. (not yet available)
Aussehen: (appearance)	farblose Kristalle (colourless crystals)
Schmelzpunkt: (melting point)	271,8°C
Acetonunlösliches: (insoluble in acetone)	0,01 %
Glührückstand: (ash)	0,01 %
Unlösliches auf US-Sieb 60: (insoluble particles)	./.
Acidität: (acidity)	0,002 % (als CH_3COOH)
Kornverteilung: (particle distribution)	> 0,5 mm 31,22 % > 0,3 mm 44,00 % > 0,15 mm 20,80 % > 0,125 mm 1,56 % > 0,075 mm 1,52 % < 0,075 mm 0,90 %
Hexogengehalt: (RDX-content)	2,2 %

- 2 -

Vakuumstabilität: (Vacuum stability)	0,13 ml	(2,5 g/100°C)
Verpuffungspunkt: (deflagration point)	274°C	(0,5 g; 20°C/min)

(Die Daten wurden aus dem Prüfbericht 2.1-2/3711/75 entnommen)

RDX-Probe für Round-Robin Test

Lieferant: (supplier)	Fa. Dynamit Nobel AG, Troisdorf
Probenbezeichnung: (sample symbol)	Lieferung vom 22.4.1974 (receiving date)
Hersteller: (manufacturer)	Fa. Soc. Nationale des Poudres et Explosifs (SNPE) Frankreich
Herstellungsverfahren: (manufacturing process)	keine Angaben Die Lieferfirma wurde gebeten, sich mit dem Hersteller in Verbindung zu setzen. (not yet available)
Aussehen: (appearance)	weiße Kristalle (white crystals)
Schmelzpunkt: (melting point)	204,6°C
Acidität: (acidity)	0,003 % (als CH_3COOH)
Alkalität: (alkalinity)	keine (no)
Acetonunlösliches: (insoluble in acetone)	0,01 %
sandige Bestandteile: (sandy materials)	keine (no)
Aschegehalt: (ash)	./.
Kornverteilung: (particle distribution)	> 0,5 mm 1,00 % > 0,4 mm 1,58 % > 0,315 mm 21,04 % > 0,2 mm 56,49 % > 0,1 mm 18,89 % > 0,05 mm 0,92 % < 0,05 mm 0,08 %
Rieselfähigkeit: (purling)	frei fließend, ohne Klumpen (free flowing, without lumps)

- 2 -

Vakuumstabilität (vacuum stability)	0,26 ml	(2,5 g/100°C)
Verpuffungspunkt: (deflagration point)	238°C	(0,5 g; 20°C/min)
NH_4^+, Cl^-, $SO_4^{=}$, NO_3^-	nicht nachweisbar (not detectable)	

(Die Daten stammen aus dem Prüfbericht 2.1-2/3729/75)

Anlage 4
zu 3.4-9/4510/78

Tetryl für Round-Robin Test

Hersteller: (manufacturer)	Fa. Dynamit Nobel AG (W-Germany) Züfa, Troisdorf
Probenbezeichnung: (sample symbol)	Charge 43, Lieferung vom 2.4.1976 (receiving date)
Herstellungsverfahren: (manufacturing process)	Stufenweise Nitrierung von Dinitromethylanilin, Stabilisierung, anschließend Umkristallisation aus Aceton und Granulierung (stepwise nitration of DNMA, stabilization, recrystallisation from acetone followed by granulation)
Aussehen: (appearance)	hellgelbes, feinkörniges Granulat (light-yellow, fine granules)
Schmelzpunkt: (melting point)	129,2°C
flüchtige Bestandteile: (volatile material)	< 0,01 %
Benzolunlösliches: (insoluble in benzene)	0,02 %
Aschegehalt: (ash)	./.
mechanische Verunreinigungen: (impurities)	keine (no)
Acidität: (acidity)	0,003 % (als HNO_3)
Alkalität: (alkalinity)	keine (no)
Kornverteilung: (particle distribution)	> 1,0 mm 14,2 % > 0,5 mm 85,8 % < 0,5 mm --
Rieselfähigkeit: (purling)	fließt ohne Stocken durch einen Trichter mit einer Öffnung von 6 mm Ø (free flowing through a funnel with 6 mm Ø stem opening)
Schüttdichte: (bulk density)	0,94 g/ml
Vakuumstabilität: (vacuum stability)	0,15 ml (2,5 g; 100°C)
Verpuffungspunkt: (deflagration point)	200°C (0,5 g; 20°C/min)

PETN-Probe für Round-Robin Test

Hersteller: (manufacturer)	Fa. Dynamit Nobel AG (W-Germany) Züfa Troisdorf
Probenbezeichnung: (sample symbol)	Lieferung vom 30.5.1974 (receiving date)
Herstellungsverfahren: (manufacturing process)	kontinuierliche Nitrierung von Pentaerythrit und Umkristallisieren aus Aceton (continuous nitration of pentaerythritol and recrystallisation from acetone)
Aussehen: (appearance)	weiße Kristalle (white crystals)
Schmelzpunkt: (melting point)	141,4°C
Stickstoffgehalt: (nitrogen content)	17,7 %
Acidität: (acidity)	$<$ 0,001 % (als HNO_3)
Alkalität: (alkalinity)	keine (no)
Acetonunlösliches: (insoluble in acetone)	$<$ 0,01 %
sandige Bestandteile: (sandy materials)	keine (no)
Bergmann-Jung-Test:	0,3 ml/g
Abel Test bei 80°C:	keine Färbung innerhalb 60 min (no color in 60 min)
Korngröße: (grain size)	sehr fein, wegen elektrostatischer Aufladung nicht bestimmbar (very fine, because of electrostatic phenomena not determined)
Rieselfähigkeit: (purling)	rieselt ohne zu stauben, keine Klumpen (free flowing without dust, no lumps)
Vakuumstabilität: (vacuum stability)	0,64 ml (2,5 g; 100°C)
Verpuffungspunkt: (deflagration point)	203°C (0,5 g; 20°C/min)

(Die Daten stammen aus dem Prüfbericht 2.1-2/3732/75)

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